DOCUMENT RESUME

ED 263 901 IR 011 888

AUTHOR Penrod, James I., Ed.
TITLE The Computer Challenge. [Proceedings of the Summer Institute for Computer Literacy (Malibu, California, June 20-24, 1982).]
INSTITUTION Pepperdine Univ., Malibu, Calif.
PUB DATE 83
NOTE 130p.; Funded in part by the Sperry Corporation.
AVAILABLE FROM Pepperdine University, Malibu, CA 90265.
PUB TYPE Collected Works - Conference Proceedings (021) -- Viewpoints (120) -- Reports - General (140)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *College Administration; *Computer Literacy; Computer Simulation; Educational Planning; Higher Education; *Information Systems; *Microcomputers; *Technological Literacy; Telecommunications
IDENTIFIERS *Computer Uses in Education; Electronic Mail; Pepperdine University CA

ABSTRACT

The Summer Institute of Computer Literacy, held at Pepperdine University in 1982, dealt with the uses of computing in higher education administration. These proceedings contain papers from presenters at the Institute. Every presentation paper could not be obtained; in such cases permission was secured to print a previously published paper authored by the presenter on the same topic. The papers include: (1) "Computer Literacy: How Do Universities and Colleges Prepare?" (Arthur Luehrmann); (2) "A Technical Introduction to Computing" (Michael M. Roberts); (3) "An Overview of Computing in Higher Education" (Charles R. Thomas); (4) "Modeling and Simulation" (Daniel A. Updegrove); (5) "The Automated Office" (Samuel J. Kalow); (6) "Planning for Integrated Campus Information Systems" (John W. McCredie); (7) "Data Base Management Systems" (John W. McCredie); (8) "A Plan for Action" (John F. McManus); (9) "Decision Support Systems" (Larry N. Craft); (10) "Social, Ethical, and Legal Issues of Computing" (Kenneth H. York); (11) "A Telecommunications Survey" (Paul S. Heller); (12) "The Commitment of Pepperdine University to Computer Literacy" (Howard A White); and (13) "The University Computer Challenge" (Jean-Jacques Servan-Schreiber). The concluding chapter, "Synopsis of an Institute" (James I. Penrod) contains a capsule report of the primary points of each presentation as given during the institute. (JB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED263901

EDITED BY JAMES L. PENROD

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

IR011888

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Jackie Smith

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

THE COMPUTER CHALLENGE

Edited by James I. Penrod

Pepperdine University
Malibu, California

3

Copyright © 1983 by Pepperdine University. All rights reserved. Printed in the United States of America. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or any means, electronic, mechanical, photocopying, recording, or otherwise without written permission of the publisher, Pepperdine University, Malibu, California 90265.

CONTENTS

PREFACE VII

1. Computer Literacy: How Do Universities and Colleges Prepare? 1
   Arthur Luehrmann
2. A Technical Introduction to Computing 13
   Michael M. Roberts
3. An Overview of Computing in Higher Education 21
   Charles R. Thomas
4. Modeling and Simulation 31
   Daniel A. Updegrove
5. The Automated Office 43
   Samuel J. Kalow
6. Planning For Integrated Campus Information Systems 51
   John W. McCredie
7. Data Base Management Systems 61
   John W. McCredie
8. A Plan for Action 71
   John F. McManus
9. Decision Support Systems 87
   Larry N. Craft
10. Social, Ethical,and Legal Issues of Computing 93
    Kenneth H. York
11. A Telecommunications Survey 101
    Paul S. Heller
12. The Commitment of Pepperdine University to Computer Literacy 111
    Howard A. White
13. The University Computer Challenge 115
    Jean-Jacques Servan-Schreiber

SYNOPSIS 121

THE COMPUTER CHALLENGE

Preface

During the summer of 1981, the editor of this particular publication attended a management institute for college and university administrators. The thirty-five participants greatly valued this educational experience. One segment of the institute curriculum dealt with the uses of computing in higher education administration. Both the formal and informal discussions resulting from the computing presentations made it very clear that a complete institute could and should be devoted to the subject. Thus was born the idea for the Summer Institute for Computer Literacy.

The concept was presented to the senior administration at Pepperdine University, to Charles R. Thomas, executive director of CAUSE and to Dr. John McCredie, President of EDUCOM. All agreed that such an institute would be worthwhile and that it could be appropriately sponsored by a university and two professional organizations, so planning for the "University Computer Challenge" began.

The planners decided that the institute should provide both a significant "hands-on" microcomputer experience and an introduction to a variety of subjects related to computing that impact all college and university administrators. The results of the second objective just listed comprise the pages of these proceedings.

Unfortunately, papers from every presenter could not be obtained for this publication. In such cases, where possible, permission has been secured to print a previously published paper authored by the presenter on the same topic. "Synopsis of An Institute," the concluding chapter, contains a capsule report of the primary points of each presentation as given during the institute.

Partial funding for these proceedings has been provided by the Sperry Corporation. Special thanks go to Al Green, vice-president for

Western Operations, Sperry Corporation for his support of this project.

Similarly, Doug Sims, president of the Automated Office (the Van Nuys, California distributor for the CPT Corporation) deserves special recognition for supplying the thirty-five CPT 8100s and assorted peripheral equipment used during the institute.

Other companies which sponsored special events helping make the institute possible include: Anacomp Micrographics, Long Beach, CA; Comco Systems, Inc., Lawndale, CA; IBM Corporation, Universal City, CA; Integral Systems, Inc., Walnut Creek, CA; Systems and Computer Technology Corporation, Malvern, PA; and Tayco Business Forms, Newbury Park, CA. Each is deeply appreciated for their meaningful assistance.

Charles R. Thomas, Debbie Smith and the CAUSE staff, John McCredie, Carolyn Landis and the EDUCOM staff, Peter Quan, John McManus, Nancy Hughes and the Pepperdine University Systems and Planning Staff are all due special recognition for their roles in planning and in successfully implementing plans for the institute.

Grateful appreciation is expressed to each of the speakers (individually recognized elsewhere in this publication) for their careful preparation, expert delivery and thoughtful interaction with institute participants.

Sandi Linville and Don McGlashen, from the University Affairs office, Pepperdine University, are due thanks for their assistance in editing and preparing the papers in this document for publication. Special appreciation is accorded to Keith McFarland and Patti Yomantas for their assistance in this project.

Finally, a special recognition goes to each of the institute participants for their enthusiasm, involvement, and individual contributions to the overall success of the institute: Joseph Abruscato, University of Vermont; Thomas Bass, California State University, Long Beach; Richard Breslin, Iona College; Donald Bull, Community College of Allegheny County; John Carrier, East Texas State University; Robert Colombatto, DJMC Advertising; Angela Coop, University of New Mexico, Los Alamos; John Engroff, University of Vermont; William Haifley, California State University, Long Beach; Lawrence Hendrick, Sacramento City College; Norman Hipps, St. Vincent College; Dorothy Jackson, University of Houston; Sung Lee, Michigan Technological University; Karen Peterson, University Systems of New Hampshire; Helen Polly, University of Missouri; Jean Rey, Faculty of Medicine—Enfants Malades; Walter Ross, Pepperdine University; Charles Runnels, Pepperdine University; Sara See, Evergreen Valley College; Byron Skinner, San Bernardino Valley College; Debbie Smith, CAUSE; David Steegar, Campbell University; Joan Stoddard, Crafton Hills College;

Sandra Suttie, Oregon State University; Martin Van De Visse, Community College of Denver; James Walker, Hastings College; Thomas Weckesser, University of Dayton; Gordon Wells, Pepperdine University; James Wilburn, Pepperdine University; Rolland Woodbeck, University of Wisconsin—Whitewater.

March 1983 James I. Penrod

1

COMPUTER LITERACY: HOW DO UNIVERSITIES AND COLLEGES PREPARE?

Arthur Luehrmann

Arthur W. Luehrmann is co-founder and a principal in Computer Literacy located in Berkeley, California. Prior to founding Computer Literacy, Dr. Luehrmann was associate director for Computing Activities at Lawrence Hall of Science, a museum and community resource center affiliated with the University of California, Berkeley.

With two general lines of thought, I will provide a retrospective of my involvement with computing for the past dozen years and explain how my own viewpoint about educational computing has changed since I was a graduate student and first encountered the computer as a tool for physics research. I began as a physicist. A renegade now, I occasionally read some literature, but pushing back the frontier of physics is not what I do anymore.

I will first tell you about my own odyssey through educational computing and secondly, I will deal with what computer knowledge students have when they reach colleges and universities. Their knowledge about computing is growing at a formidable rate. The expectations that students bring with them is changing very fast and that has some strong implications for what colleges will have to offer to those students to keep them interested in coming. There are fewer of them, so attracting them is going to be more and more important for leading institutions.

My first brush with the computer, I said, was as a tool. I needed it to solve some problems for a thesis I was doing in theoretical physics. It was an elementary set of computations, but they had to be done about a million times. I knew I would make mistakes. So it seemed better to

commit the whole thing to a computer program, tell the computer how to do the job, and let the computer do it. That concept interested me and I became intrigued by computers then, which may have affected my choice of a first job.

I went to Dartmouth College, which in many people's minds is represented by snow-sculptured statues and old black and white movies about winter carnival and shenanigans and nothing very substantial. When I got there I found a new creature on campus called the timesharing computer system, absolutely state of the art. Timesharing had just been conceived a couple of years earlier. Some folks at the Massachusetts Institute of Technology thought it would be neat for one computer to serve a lot of people through a teletype machine. Remember teletype machines? John Kemeny and Tom Kurtz at Dartmouth said, well, we can do that too; only we can do it friendlier and cheaper. They received help from the National Science Foundation and a cadre of bright, talented young undergraduates and put together a remarkable timesharing system. Up to twenty-four people could sit before their terminals and write and run programs. Within a few years the number increased to around forty. It was on a clunky machine according to today's standards. The amount of memory was minimal. The standard Apple computer, for example, offers about eight times that much right now, and that will quickly escalate by another factor of about four or five in the next year or two. So the computing power was really very limited, but it was available to everybody; every student on campus had access to this computer at no cost. It was a novel idea that you could use a computer system and not bill for it. Well, there were bills, but they were sent to the dean, not to the students.

So suddenly terminals appeared and even in the library some quiet CRTs started popping up. In the sociology department, a basement room had about sixteen teletype machines and the students were doing statistical analysis on enormous sets of samples, enormous by the standards of what students were able to do with quantitative analysis in the social sciences before that day. They could formulate a theory about something, go to the census data, and see whether the theory held water or not. They could do simple analysis, analysis of variance, frequency tests, and a number of other things. It was designed for student use. It was not designed like SPSS to be a research tool that only the priesthood could manage. This was for folks, smart folks, but folks.

In a class taught by a geographer and an economist the students used a computer for role playing. They ran a town. The computer model could be set up for everything from a grass field in Kansas to an urban area. In this case, it was set up as a smallish city, and the students

played various roles in the city, made decisions, entered them into the computer and saw the economic cycle of several years pass by every week. So they had the experience of using a computer model. The teachers found that when it came time to theorize and try to back off and see what was going on in real cities, the students were more interested and had different sets of concepts than they might have received from reading a book.

The game board was just cardboard; the real game board was the computer. The computer was the one who said how to set up the cardboard board and the students followed the directions of the computer.

The students would meet once a week in town meetings, good old New England style, and discuss common issues: paving roads, utilities and tax rates.

I was there one day when theft occurred in the city for the first time. It was a wonderful experience. One of the teams had left its game password available. Leaving it available probably meant leaving it crumbled up on paper and thrown in the trash bin. A member of another team acquired it, opened the first team's account, and transferred all the money and goods into their team's account. They then changed the password. The other team could not even get back into its own account.

Well, the team that had been sinned against was furious. "You must have rules; you must have a common basis in order to have a community;" that was their argument. Well, sure. Lots of people have said that since Plato and Aristotle. But it came out in a vivid kind of emotional context. The other team said "you should not have left it in the trash bin; you were not guarding your property. You know, if you leave your door unlocked and somebody goes in and takes something out of your house, it is different from leaving it locked and having somebody break in. There are degrees of immorality."

This was a case of a person who was grappling with a basic moral and social issue in the context of a game. Nothing was really lost, but it was as though something terribly important had happened. Later on they could back off out of that game context and meet in seminar and talk about that whole issue.

In the United States, students are taught very little music and almost no composition. Very few students, by the time they get to college can perform on any instrument. What do you do if you want to teach composition? How can you learn composition, when there is no hope of hearing what you have composed? You cannot. The only way you can teach composition traditionally is to teach it to students who have some performing skills, so that they can create a piece, perform it, and hear it. Well, this fellow at Dartmouth had the idea that a computer

language could be written so that students could tell the computer what the composition was and accordingly, the computer could then make the sounds. So a little bit of hardware had to be created (not too much, nothing fancy). And this little language was created. The music looks like a computer program. It has line numbers, commands, statements, and all of that. It can be edited like computer programs. The student would sit down at a computer terminal and enter a composition. There was a little stereo system attached to the terminal, and when the student was ready to hear it, the command was given. I think it was "sing." Then the composition was played back. The student would say, "No, that's not what I like," and delete some lines, change some lines and run it again until it was satisfactory, and then submit the composition to a file which the teacher would then be able to peruse at a later time. That was a novel use of computers: to teach something that was hard to teach otherwise and with great success. (Enrollments in the composition class went up very fast.) This was a very trivial language, by the way, and more interesting ones were developed later on. This one only had about twelve sounds and only four of them were pitched. The teacher found that if you give students lots of pitches they do not create music. They create melodies, little melodic sequences; but they do not ever try to organize anything into a whole. Composition is organization, not just making tunes. So he just robbed them of the ingredients of making tunes and gave them sounds instead.

I personally got suckered into this field because, as a physics teacher, I found that I could teach more honest-to-goodness deep physics if I took a week from my packed curriculum and taught just that much programming.

Professors like to think that students must know calculus before they take physics. That is not the case. They may have had the course, or may be taking a course concurrently, but their comfort or belief in their ability to do anything with the calculus is pretty slim at that point in their lifetime. With the computers, on the other hand, the same basic ideas that can be written in the form of differential equations can also be written in the form of difference equations. Those look just the same except you can compute them. You can tell the computer how to move one little step after the next; you can define a small time interval and then you can move your particle from place to place to place just the way Newton said. Those principles could be taught and the students really believed it because they were able to do it themselves. They could apply the methodology they learned by writing their own programs and then they were able to explore much deeper physics. These experiences moved me almost totally into computer education.

When I left Dartmouth in 1977, I went to the Lawrence Hall of Science with the notion that computing was an undergraduate subject. I was wrong. Now the Hall is an interesting beast. It sits on top of the hills in Berkeley with an absolutely spectacular view all the way across the bay, San Francisco, three bridges. It has everything—except funding. The University of California, in its wisdom, created a plan and a name and a bunch of office space. It tidies up the place and cuts the lawn, and gives it five percent of its operating budget. And so, the Hall has to do some very creative things.

The Lawrence Hall of Science is part of the Berkeley campus of the University of California, but it does not serve any of the campus clientele. It has a public face. It is a memorial to Ernest Lawrence, the great Berkeley physicist who started and developed one of the very first cyclotrons and made physics a strong department on the Berkeley campus. When he died, a memorial was decided upon, an active memorial; not just a plaque or a monument, but a place with a program. Its goal is to improve science education in schools.

There was one magnetic attraction at the Hall. It was the time-sharing computer, and it drew people like crazy. I noticed that the faces of visitors seemed to be a little bit younger, yet they seemed to be experiencing what the Dartmouth undergraduates had experienced. I thought, maybe computing is even accessible to high school students. It was very exciting.

We did several surveys to determine what made people come to the Hall, what they liked to do, what they did the most and the longest. Computing almost always ranked high. They would spend more time at a computer exhibit than at any other. In other museums there is always an exhibit where you watch eggs hatch. When we measured our computer attractiveness and holding power against hatching eggs, the hatching eggs won, but not by much.

When I arrived at Berkeley, the microcomputer had also just arrived on the scene. The Commodore P.E.T. had been announced about a year before and they were actually beginning to deliver. This machine, from its specifications, sounded pretty terrific. We thought that was interesting. So we actually paid some hard-earned money to buy micros. We did some shopping at the West Coast Computer Faire. At the fair, I found that ordinary people had discovered the computer.

Well, we received our Commodore P.E.T.s and we used those as an alternative way of running our classes at the Hall. Kids would come up after school, and they would have a class on their own. Adults would come in the evening. Two or three years ago, we counted forty thousand enrollments a year.

The P.E.T.s were very successful. They worked quite well. They had some serious disadvantages, but we were so encouraged that we

started getting other computers. By that time we had aroused the interest of other manufacturers and we did not have to pay for any more computers after our first dozen. By the time I left we had about seventy-five microcomputers of all the brands you ever heard of, but enough of each kind to run a separate, integrated lab.

One of the last things I did at the Hall was start a program to take computers out to schools. As I said, the Hall is on a lovely site on the top of a hill on the Berkeley campus, but there is no public transportation. To get there you have to come on a bus, or drive or live close enough to walk. That pretty much limited the access, so I thought it would be interesting, now that micros were here, to take our program out of the Hall. So we designed and built some carrying cases. We latched on to a van that the Hall was not using and we created a program. We would send one or two teachers, who were also furniture movers and drivers. They would unload these carts, each of which had three Apple computers and television sets. The van would hold four such carts, so twelve computers could be taken out and set up rather quickly. The wheeled cases became tables inside the classroom and we also carried some doors with hinges on them so we could attach them and they would become table tops. In a short time the computers would be positioned along on the tabletops. Before long we had a classroom working right at the school. It was a howling success, much better than at the Hall. The Hall has been used as the backdrop for science fiction movies. It is a spacy place. When teachers bring a bus load of kids up there, it is like going to Oz. We were wizards, we could do anything. The teachers could, with all good conscience, go down to the cafeteria and leave it up to us and our teachers. Then they could pick up the kids at the end and take them home. But our van program was invading their space with rinky dink equipment that they could afford themselves. We required the teacher's attendance. We said it was the teacher's class and we needed someone to be disciplinarian, and such. But the real reason we required the teacher to be there was to see how easy it was. There was no magic. It kind of pulled that curtain away from Frank Morgan, who was playing Oz, and let them know that there was nothing magic about it. They could do it themselves, and sure enough, many picked up on it. The principal would stroll by the room and see the kids happily at work and say, "You know, we could have a program like that." I believe we had logged about six thousand miles per year on the vehicle running that program when I left, and it is still going on. We knew by looking back a year or two later, that schools that had been visited were in fact in a very strong shopper's frame of mind. A year or two later they had their own computer labs and stopped calling up the Hall.

What I found during those years, especially during the last three or four years, was a sudden enormous growth in teacher interest and pre-college student interest in computing. We hosted a meeting at the Lawrence Hall of Science, the first annual meeting of a group calling itself Computer-Using Educators. It was created by three people sitting around in their living rooms, saying "Don't you think we ought to have a teaching organization for people who are getting interested in teaching computers?" Somebody else said "Yes, that would be neat; let's have an organization." It was like one of those old Judy Garland-Mickey Rooney back-lot MGM movies. "Let's have a show. Let's have an organization." They decided to organize it and we offered to host their first meeting. We had sixty teachers who spent all day Saturday at their own expense to share ideas with one another about computer education. I thought that was really fantastic. The next year I was a keynote speaker at their second annual conference, which was held at a high school in San Jose. They had six hundred teachers come out and spend all day Saturday. There were three or four parallel sessions and forty or fifty computers; it was quite impressive. Last year, they held a third meeting and there were approximately fourteen hundred teachers and I expect this fall, attendance will top two thousand.

If you want to know the least about educational computing, pre-college, go to Washington; go to the Department of Education. If you want to know the next least, go to your state department. If you want to know people who know a little bit more, go to the county. If you want to know what is really going on, go through the district and down to the teachers and the parents. Parents are pushing and the teachers are interested; not every teacher in every school is fascinated by computers, but enough are. The cost of computer equipment is no longer an obstacle. It sounds like a lot of money, but when you compare it to other school costs, it is small. The one-time cost of equipping a computer lab in a school is almost comparable to the budget for books, which is about three-quarters of one percent of the school's operating budget. It is just not that expensive.

Let me tell you what I see happening at the pre-college level. Computer education in the minds of many people means replacing a teacher with a computer to do math drills, teach spelling, etc.

Although we hear a lot about this mode of use, it is not practical as much as some of the other modes. There are three main ways that computers are involved in education. A student can learn *from* the computer, *with* the computer, or *about* the computer.

In the mode of learning *from* the computer, the computer carries out teaching and managing tasks that are normally done by the teacher. It delivers information, it asks questions, it gives drills, it gives

tests, it does record keeping, and it may do some diagnostics.

The idea of learning *with* the computer is that students use the computer like a powerful calculator, analyze some data, run some statistical routines, or do some experiments with models.

A nice example of this is showing up in high schools in history class, a little model called the Oregon Trail. You pretend that you are a family embarking on a trip west along the Oregon Trail and you must decide how you will outfit yourselves. You cannot take everything. You must provide provisions along the way. So if you start with too much your oxen or horses will not make it, and so forth. Things happen to you; you get surrounded by Indians, you run out of things, sickness occurs, all kinds of things. But you get to start over. That is the nice thing about the model as opposed to the poor folks who made the wrong decisions in the real world.

Well, the point here is that it is hard to say whether the computer is doing any teaching, but in the hands of a skilled teacher, it becomes at the very least a way of arousing interest in a traditional subject: American history. It provokes some discussion and some thought among students about making decisions.

Learning *about* the computer is learning, at the very least, the grammar of a programming language and how to write and spell in a programming language. More importantly it gives students a way of thinking about a problem and representing it. It develops planning skills and strategies for debugging. Programs, of course, never work. So if one wants to make any progress, one has to learn debugging strategies. How do I fix it? Where is the flaw in the logic? How do I put probes in and tease it out?

These are deep reasoning skills, they are not just tools of the programmer. Writers have bugs in many arguments they make in English. A careful writer reads over what was written and debugs it. What is wrong with this thing? It does not say exactly what I meant or does not follow from the argument I was presenting. Debugging strategies are terribly important.

So are planning skills. There is no way to write a long computer program or a long paper without planning. The exercise is very similar whether writing for a computer or writing for another person. If you are intending to produce a long work, you must invest a great deal of time at the outset. Without a structure that will support its weight it collapses somewhere along the way. Most kids who learn programming on their own, think that the way you write a program is to write as many lines as you can and then write another one, and then another one and then another one and then another one. It is like a house of cards — and eventually it will fall into a heap. It takes a skilled and properly trained teacher to show students how to plan and debug programs.

I think that of the three modalities, the one that is certainly secure is learning about the computer. That is the subject that is going to be in the curriculum of every school in the United States in the next three to five years. It will be at least a one-semester course that just average students, the non-college bound and the college bound alike, will take. It will be one of the things you do in junior high, or maybe earlier.

I used to think that computing was a graduate subject and now I have settled on junior high. Well, maybe it belongs in sixth or fifth grade. The work with LOGO suggests that many of these deep ideas can be introduced even earlier with the right language. So I do not know truly where it belongs. But I believe that every school in the United States and other countries as well will admit computing under some name, probably "computer literacy," as a subject that belongs in the curriculum early.

Then schools will face another problem: The kid has had two semesters in junior high, so what happens in high school? What are the student's expectations about what will be available to learn in high school? As many of you probably know, the College Board and Educational Testing Service (ETS) are defining an advanced placement computer science course. That will give an impetus to many high schools, larger ones in particular, to teach computer science. So you college folks may have students arriving with four semesters of computing behind them: formal instruction, not just hacking around on the computer playing games, but formal instruction — what do you do with those folks?

Next subject — benefits and costs. It is important for people to recognize the costs and benefits of these different modalities of education computer use. The main benefit from Computer Assisted Instruction or CAI (learning *from* the computer) is that the instruction is self-paced. The instruction stops until the student makes a response, which does not happen in the conventional classroom: Instruction rolls on like a steamroller. The below-average student gets steamrolled and the ones who are above it get bored. CAIs big advantage, I think, is the self-pacing. Although reputedly individualized, there is very little individualization in fact. By individualization I mean that if the student gets a wrong answer, the program then branches to a set of questions that are easier or harder or remedial or diagnostic. This material is difficult and expensive to write. So most people just stay with the main line and may cycle the student back to repeat a problem, but that is about it. On the other hand, CAI is consistent and patient. That is important, especially in dealing with minority kids where there may be some built-in bias on the part of the teaching staff. The computer simply does its number and it does not get tired or

lose its patience. CAI is also fast. The studies of CAI projects have shown that students typically complete a course with one-third to one-half of the contact hours between the student and the computer, compared to the student in a classroom setting with a teacher. Now that does not help too much: not too many parents would be tickled silly that their kids come home at noon instead of three o'clock. Schools are still custodians. In military training or industrial training the pay-off is handsome because the trainer is paying the wages of the trainee. If the job can be done twice as fast, that is money in the bank.

CAI costs a lot of money. It is not only the equipment, but it is the cost of producing good computer-assisted instruction software. That cost is much higher than anyone ever dreamed. It probably takes about a thousand hours to produce an hour of material. It is not very different from movie production costs; therefore, it needs the kind of market that a movie needs to be a commercially successful product. Practically no one has made that investment so we really do not know what good CAI would look like.

The benefit of learning *with* the computer is that the students learn a new tool. They see the computer as something to be used routinely in solving a problem. It is just part of the landscape. Sometimes, as in running models, the models may be mathematically very complex. The student does not have to know about that to interact with the model. The equipment costs much less than for CAI. Remember in CAI, it is one student on one computer. But with this mode, the computer is like audiovisual equipment. You put it on a wheel base and wheel it into the classroom. The history teacher says, "I want it Tuesday, third period, because I'm going to do Oregon Trail." So Tuesday, third period, the computer is there, with a big monitor sitting on top of a stand. The teacher uses it the same way a videotape might be used. It is pretty cheap. The school could have several computers of different brands to run all the different kinds of software that a teacher might want. Software, on other hand, is expensive. Every time you want to have a new simulation, you buy another set of diskettes costing from $30 to $100. It also takes time from other classroom activities. Any time you introduce a new way of teaching something, you have to ask yourself, "is this more or less important than what I was doing before?" Anyway, this mode is relatively cheap and schools are using a lot of it.

In learning *about* the computer the big benefits are what the kids learn. They learn a new set of skills. They learn new subject matter, new information, and new methods. The question is: "Is it worth teaching at all?" And if so, how much is it worth? What are you prepared to kick out of the curriculum to make room for it?

The career options for the students are indicators of the benefit. I

just read recently that IBM has said that as early as 1985, three-quarters of the jobs in the United States work force will require direct or indirect interaction with computers. Half of the jobs about four years ago were found to be in information, so I think this is a reasonable prediction. The work force in the United States has changed in a hundred years from almost totally agricultural to fifty percent information, about twenty percent manual labor, and about five percent agricultural. Most of the employed people today process information. They do not do physical work. The computer is the information machine. So career choices will depend more and more on our abilities to use information and computers. Vocational dollars are a little different from career options. Career options mean being trained for the next twenty, thirty, or forty years. Vocational dollars mean being able to get a job next week. If you have some programming skills you can. So those are the benefits. The parents know all this. That is why they are pushing for computers. They want their kids to have a shot at the future and a job when they get out of school. They are willing to support the cost to the school.

On the cost side, the computer course is a new course and something has to give. That is always tough if you are a school administrator. What course do you delete? I try not to get caught in those situations when I am asked. I guess if I were taking a ten-year perspective it would be plain as day what course has to give way, and that is shop. You can teach a robot how to bend a sheet of metal better than you can teach people how to do it, and the robot runs in a cold room in the dark, and does not strike. So it is inevitable.

Another cost is teacher training. There will be millions of kids taking a course from somebody who was never taught how to be a teacher in that subject. Think of that problem for society. How will you train teachers? This is a marvelous opportunity for universities. But who will teach those teacher education courses? Universities have a hard enough time teaching undergraduates computing and keeping a computer science department. Yet a market exists out there for the university that solves the problem. A few schools of education have already responded. Most schools of education see teacher training as a dead end for the next decade. There are too many teachers now. But there are shortages in mathematics, for example, and there are certainly shortages in this new field which is emerging. So it is a problem and an opportunity.

Nobody is truly resistant to buying equipment for a course like this. It turns out that you need about eight computers (maybe sixteen, if you really would like to have one student work alone on computer problems). Working in pairs has some advantages in this mode. While working together on a computer problem the dialogue between the

students can be very helpful in solving the problems. Eight computers just do not cost much anymore. Schools should be able to buy computers in the next three or four years at prices close to typewriter prices.

Since teacher training opportunities are now terrible, and the demand for the computer literacy course is very high, you can also expect that students will arrive at the college door with poor quality instruction in the subject. Your computer science department will have to deal with the need for what I call "orthodontic" courses: Your kids have all their teeth, but they are crooked and need to be straightened. That will be the case until the computer science community finally wants to get into the act and do something about pre-college education. They complain about the bad habits that students have when they come to colleges and universities. That is unfair. If they want to change that they should get involved in the instruction of teachers. Somebody has to write books to teach teachers how to be teachers of computing. Nobody is doing that.

There are unsolved problems, but the whole process is going on; it is happening with ugliness and beautiful things happening at the same time. It is disorganized. But it is happening and will bring students to higher education's door. They will expect things to be better in college than they were in high school. And they will be disappointed in many schools. They will find that the situation is worse. I know many students who have left a high school with good access to computers for a university which has an abundance of computers, but little or no access for students. High school seniors will probably shop. When they apply to schools, the students will probably ask how good the computer facilities are.

Despite these adjustment problems, the whole process is good news. The ability of students to learn these subjects in schools before they get to college is wonderful. It is the best way to do it because it is cheap and it works. Although the subject will not be taught in the best possible way for all students, the number who can be served this way is enormous. I think that it is a good thing. It will bring subtle pressure on colleges and universities (and maybe not so subtle pressure) to acknowledge that students come with new skills and expectations. The faculty ought to respond to that, make use of those skills, and integrate them into the course offerings that they have already.

2

A TECHNICAL INTRODUCTION TO COMPUTING

Michael M. Roberts

Michael M. Roberts is deputy director, Center for Information Technology, Stanford University. He is co-author and editor of various technical and resource management planning documents including "Stanford Computing Strategies, 1978-1983." Mr. Roberts was the first president of the CAUSE Board.

This chapter will provide an overview of the technical side of computing and information technology, an increasingly large and complex subject area.

First, two brief introductory points: As a practitioner, one who stands daily in the midst of technical and operational turmoil, I have the potential loss of perspective, for good or bad, that results from that position. Second, computing is adopting new roles in our culture and society, and old assumptions and conclusions need to be restated and revalued. This chapter will not end with a series of conclusions. I have selected a few issues framed as questions to provide a structure for Socratic thought.

This chapter is divided into four sections. The first will provide historical background and identify a few of the antecedents which influenced the development of modern computers. The second covers the technology available today and some of its logical structure and interrelationships. The third deals with several aspects of the complex software field, and the last deals with electronic networking and distributed processing.

Copyright 1983, Michael M. Roberts.

HISTORICAL BACKGROUND

The name of Charles Babbage is widely associated with the origins of modern computing. He was a wealthy, well-connected, brilliant and eccentric British scientist of the early nineteenth century. A product of the Industrial Revolution, he both designed and supervised the construction of his machines. His successful Difference Engine, used to construct tables such as those for firing artillery, was a forerunner of the Analytical Engine; its design provided for storing programs on cards, and for changing a series of computations based on intermediate results. Unfortunately it was never completed, nor were several other creative designs, despite the fact that he expended nearly all of his fortune on them.

Ada Lovelace was the only child of Lord Byron's first marriage. Her mother was strong willed and unconventionally encouraged Lovelace's mathematical talents. Despite ill health, marriage, and three children, she became a close friend and colleague of Babbage's, preparing several design documents, including one for the program storage cards. The Analytical Engine might well have been finished if her life had not been cut short by cancer. She is now a figure of some mythology, nominated for the title of the First Programmer, and has had the new language, ADA, named for her.

Near the end of the nineteenth century, Herman Hollerith's tabulating machines could perform all four arithmetic functions, putting in place the foundations of automated data processing for business purposes.

The Aberdeen Differential Analyzer was constructed in the thirties at Aberdeen Proving Ground for the Army Ballistic Research Laboratory from designs done at MIT by Vannevar Bush and his colleagues. Only a few of these devices were constructed anywhere in the world and were used in solving problems of physical science and electronics, including that old friend, firing tables. In many respects, it represents the high water mark of analog mechanical computers.

The ENIGMA enciphering machine, based on adjustable rotary discs, was used to encrypt military messages. Considerable impetus to the development of electronic computers was exerted by the British and American code-breaking programs, the British effort based at Bletchley Park being the more famous. The Colossus machines had many features found in today's computers but their ability to contribute to the advancement of computer technology was severely inhibited by military secrecy.

The ENIAC is considered the first general purpose electronic computer. It was sponsored by the Army to calculate ballistic tables faster than the differential analyzer. For $500,000, J. Presper Eckert, John Mauchly and their distinguished team constructed a device

weighing eighty tons and containing over eighteen thousand vacuum tubes that computed at four hundred multiplications per second —one hundred times faster than the analyzer. The basic cycle time was ten microseconds. It could compute the trajectory of a shell in twenty seconds, but the program setup time was two days.

How can universities best exploit the price performance of 'mass market' computers? How should we deal with the 'Chevrolet' versus 'Cadillac' argument? Where on the spectrum between complete control and laissez faire should we be?

Commentary

Universities have been responsible for a remarkable number of contributions to computing technology that have found their way into commercial products. In the early years, this special knowledge and competence provided an opportunity for introduction of systems and hardware uniquely suited to the academic environment. The consumer mass market for personal computers now enables the acquisition of computing power at extraordinarily low cost, but at the same time it requires that we fit our requirements to these new products, rather than fitting the products to our needs.

It is traditional in academia to foster both breadth and equality of opportunity while at the same time rewarding demonstrated skill and achievement. Along several dimensions, this latter characteristic fosters 'haves' and 'have nots.' Differential access to computing resources contributes to the current gap between the computer literate and the computer illiterate communities in our institutions. Mechanisms must be found to balance the contending claims of those who desire resources for all, and those who wish to allocate them to the most talented and accomplished.

The scarce and expensive first three generations of computers spawned bureaucratic and largely centralized control mechanisms to attempt to ensure their effective use. With quite powerful personal computers reaching the cost of a typewriter, these controls are inappropriate for their original use, but we may find it desirable to retain some of them, redirected toward support of interconnections among the large number and variety of machines which are proliferating throughout our campuses.

SOFTWARE ENGINEERING

Applications' development, frequently known as "Administrative Systems," is a troubled area, both in higher education and in the private sector. Six years ago, difficulties with applications' development were identified as the single most important obstacle to increased use

of computers in society. A good deal of focus is being given to the provision of better tools and techniques for development, with an emphasis on engineering approaches previously applied in other disciplines. A major field of software engineering is emerging.

The major stages in a typical systems development project have been identified as (1) System requirements, (2) Software requirements, (3) Preliminary design, (4) Detailed design, (5) Code and debug, (6) Test and install, and (7) Production operations and tuning.

Another parallel computing development was the electromechanical Harvard/Aiken Mark I, which used punched paper tape to control its operations. It could not compete with all electronic digital designs and was the last of its line. IBM played a major contributory role in its construction and Thomas Watson Jr. felt ill-used by Aiken because of his lack of recognition of the company's role.

In nearly total isolation from computing developments in other countries, Conrad Zuse developed a series of programmable digital computers in Germany of which the Z4 Computer was the last.

The Cambridge EDSAC was a lineal descendent of the ENIAC and contributed to early experience in programming. It is characterized by an academic "open architecture" style of construction.

IBM was slow to invest in the fully electronic stored program computer. Following the wide publicity associated with use of the Univac I in analyzing the presidential election of 1952, the company sent out thirty letters of solicitation for the 701, and got thirty orders back. Only nineteen were built, as the design was superceded by the 704.

REVIEW OF CURRENT TECHNOLOGY

In the thirty years since the first commercial electronic computers, some four generations of major improvement have occurred. The vacuum tube first generation was followed by the transistorized second. The third, created by IBM's introduction of the 360 line in 1963, was followed by a more diffused fourth based on large scale integration of silicon based circuits in the seventies. The enormous increase in the breadth and depth of penetration of technology into functional areas that is occurring today may have made generational labels based on hardware obsolete.

Regardless of it size, the modern computer has a logical structure very close to that worked out in the first generation. A central processing unit containing logic and arithmetic functions is connected to input and output units, and to a system control unit. Programs and data are lodged in one or more levels of memory.

The CRAY I is the fastest commercially available computer sold today. Presented with the right mathematical problem, it can perform

one hundred million operations per second, although the average rate, even when the machine is busy, is more nearly fifty million. The machine cycle time is 12.5 nanoseconds, and in order to maintain proper signal timing in the machine, its reclusive designer, Seymour Cray, deliberately chose a circular construction in which no wire connections are longer than four feet.

Performance improvement in a computer such as the CRAY-I depends largely on faster instruction execution rates, which in turn require faster and denser electronic circuits. This developmental module of the CRAY-2 is immersed in liquid fluorocarbon to carry off heat from its high density packaging. The machine is expected to have a four-nanosecond cycle time and a total MIP (millions of instructions per second) rating exceeding four hundred.

The IBM 3081 is now IBM's largest machine, with a performance rating of approximately fifteen MIPS in its most powerful model. The logic and control circuits have been packaged in twenty-seven modules. A multilayer ceramic carrier with over one hundred silicon chips is surrounded by a specialized water cooling arrangement.

Small computers are making equal if not larger technical strides than large machines. After a prolonged gestation period, Xerox introduced its Star professional workstation last year. A complete computer in a desk-size package for approximately fifteen thousand dollars, the Star features advanced terminal features integrated into a comprehensive set of user-friendly software. The Star and its companion printer and file machines were designed to operate in a networked environment using the Xerox-developed Ethernet.

Most powerful of the recently introduced desktop machines, the Fortune computer is based on Motorola's MC68000 thirty-two bit microprocessor. It can be used individually or in a cluster and features one of the first implementations in a personal computer of the Bell Labs UNIX software.

The specification of a computer application almost always proceeds in an environment of uncertainty. Various approaches have been tried to minimize uncertainty. The theoretical approach attempts to conquer uncertainty at the beginning by emphasizing complete and unambiguous requirements specification. The practical approach uses a progressive and iterative technique that provides for trial and error.

A complicating factor in software development decisions is the increasing number of options to use different generations of computer technology embodying different degrees of technical and operational maturity and stability. Thus, designers and their managers must not only select the appropriate development technique, but ensure that

the technical base on which the application is being mounted is suited to the end user requirements as well.

Each generation of technology in use is at a different stage of its life cycle, from new and untried to obsolete and expensive. This problem is exemplified in the Database Systems area, where many organizations are presently confronted with support requirements for both third and fourth generation DBMS applications, and facing the introduction of fifth generation DBMS technology over the next several years.

Commentary

Can we afford the expertise needed to support multiple development methodologies? How can the expense of supporting four generations of data processing be avoided? Will our 'artistic' programmers stay if engineering measurements are applied to their work? Can users be trusted to do their own programming?

No one wants to use last year's tool, yet if major design standards are changed too frequently, an expensive and operationally unstable potpourri of applications will result. Too few data processing groups appear to analyze the expected lifetime of their major applications and design for the expected technical environment of the later stages of their useful life.

The great fable of computing used to be emulation of a second-generation computer on third-generation hardware. Many installations now support three generations at once. Lifecycle planning can minimize but not eliminate the problem which will be with us in the same manner that our highways support automobiles of many model years.

Engineering accomplishments are not without artistic merit. A truly outstanding computer program is *measurably* better. If you cannot measure the performance of a system, then you probably do not have any reasonable idea of whether you have designed and invested wisely. Good programmers invite comparisons of their work.

A very high percentage of individuals in our society will 'program' computers in the next decade, whether trusted or not. That programming work requiring complex logic, low or zero error rates, and high efficiency should be assigned to those with the necessary professional skills to accomplish it well.

NETWORKING AND DISTRIBUTED PROCESSING

Computer networks have the potential to reduce the constraints of time and geography on human interaction in an analogous but more extensive manner than did the telegraph and telephone. Primary uses for computer networks include connection of personal terminals and

small computers to distant host machines, the transmission of files of information from one machine to another, and the store and forward functions of electronic messaging. Distributed computing relies on the existence of computer networks for its effectiveness.

Active network development began at Stanford University in the late seventies, aided by faculty interest and contributions from the research staff and students.

The present Stanford plan will use broadband cable TV technology to create a 'backbone' network linking approximately one hundred main academic buildings. This distribution system will carry, in a phased development plan, digital transmission needs for such functions as terminal to host, computer to computer, utility control, and television.

Networking technology is in a state of very rapid evolution, creating requirements for coordination of a multitude of technical specialties, including network topology, protocol definition, signaling methods, and electronic media.

Effective use of distributed computing in a networked environment will require a comprehensive set of standards. The International Standards Organization (ISO) has sponsored a draft architecture for such a set of standards, known as the Open System Interconnection (OSI). It will require the balance of this decade to fully specify this architecture and its detailed standards.

A natural hierarchy of distribution of function is beginning to emerge in which individual workstations or personal computers will be linked to local departmental systems, with connections to remote central hosts for university-wide functional requirements.

Commentary

Can we/should we operate our own network? Which comes first, office automation or the next generation of data processing applications? What do we do while we're waiting for standards? Why aren't any of the application packages network-compatible?

Computer networking on any campuswide scale is neither technically nor operationally stable at this time. Institutions choosing to go forward now will require considerable in-house expertise, or very substantial resources to acquire equivalent talent on a consulting basis. A decision to proceed would be based on a connection of networking function to primary academic and research program objectives rather than economic return.

The rapid evolution of function previously available only on mainframe machines toward smaller units, including personal computers, is requiring a rethinking of plans for major data processing applications. In many situations, the installation of a high-quality

office computer system will generate more immediate improvement in administrative efficiency and effectiveness than a mainframe-based application.

The smart computing manager will do business with those vendors committed to rapid evolution of an industry networking standard and to protection of their clients' investment as the technology advances.

An application package must be 'proven' to be saleable. To be proven, an initial production installation must occur before effective marketing can begin. The typical package is thus four to five years past its original design point when you buy it and has some degree of obsolescence. The advent of networking increases the care with which packages should be evaluated for future technical compatibility.

3

AN OVERVIEW OF COMPUTING IN HIGHER EDUCATION

Charles R. Thomas

Charles R. Thomas is executive director of CAUSE, Boulder, Colorado, a professional association for information systems in higher education. Mr. Thomas serves as a consultant to colleges and universities for computing and information systems and has authored many articles and books.

INTRODUCTION

The convergence of computing and communication, as well as the general acceleration of technology, will significantly change the way nearly every department of every college and university operates in the near future. Other technological developments like the telephone, typewriters and television are well-accepted productivity aids in both industry and education. However, the increased level of productivity possible through the use of computing and communications will be significantly greater than any of the previous developments.

Some institutions are leading the way in the use of computing in each of the major areas of administration, instruction and research; however, the full benefit of the use of these converging technologies is yet to be realized.

The purpose of this paper is to present an overview of the ways leading institutions are now using computing and communications, and to forecast some ways all institutions will benefit in the next few years.

ADMINISTRATIVE COMPUTING

Most institutions currently use computing in some form for many operational tasks, such as accounting, payroll, admissions, and student records. In addition to a wide range of operational systems, the

leading institutions are beginning to develop applications to support planning and management systems, electronic mail, word processing and desktop computing.

CAUSE now maintains a National Database on the administrative computing activities of all member campuses, and every other year publishes a monograph summarizing this database. The information in the 1980 Monograph[1] is now being used by many institutions in assessing their internal administrative computing. Some of the summary information from this most recent publication provides an overview of the current status of administrative computing in higher education. The information in the Monograph is based on responses from 350 CAUSE member campuses, representing approximately 10% of the 3,370 institutions listed in the *1980-81 Education Directory.*[2]

To provide a common reference format, most of the information in the monograph is summarized by institutional control (public or private), institution type (university, four-year or two-year), and student enrollment size (large=18,000 and over, medium-large=8,000-17,999, medium=2,000-7,999, and small=less than 2,000). The enrollment size groups were chosen to correspond to the CAUSE dues categories and because the institutions in these groups generally have similar administrative information systems needs. Where appropriate, several of the responses are also summarized by separate administrative versus combined academic/administrative computing installations. Most of the information is also presented in a format that will allow development of trend lines when data from future profiles are available.

Chapters 2 through 6 of the monograph deal with the detailed findings concerning administrative information systems organization, staffing, budgeting, computer hardware and communications, and software. Some of the major points of each of those chapters follow.

Organization

Separate versus Combined Computing Installations. Responses to the 1980 Profile indicate that the larger, more complex institutions are more likely to have separate administrative computing installations, even though 69% of responding institutions report combined academic and administrative installations. Separate administrative installations are reported by 43% of the large universities and by only 10% of the two-year institutions.

Reporting Level. Colleges and universities are following a general trend evident in industry with the administrative information systems organization reporting to the vice-president or higher level in almost three-fourths of the responding institutions. As institutional size and

complexity increases; however, it is more likely that AIS will report to an office below the vice-president level.

Staffing

When detailed information about full-time equivalent (FTE) staff in each administrative information systems organization was analyzed by five major staff categories, little difference was noted among the major institutional groups. The distribution for all responding institutions was:

Management	11%
Analysts/Programmers	38%
Systems Programmers	7%
Operations	34%
Clerical	10%

Only information reported by small institutions varied more than 1 or 2% from this distribution. In those institutions, the actual distribution of effort is probably similar, since each staff member may handle tasks in more than one staff area.

When compared to similar information five years earlier from the *Fourth Inventory of Computers in Higher Education*[3] (FICHE), the share of clerical staff shows a drop from 15% to 10% of total staff, and the management staff decreased from 14% to 10% in public institutions and from 18% to 13% in private institutions. The operations staff category has remained at 34% since 1976. The 1976 information did not differentiate systems programmers from analysts/programmers, so the 34-37% reported in 1976 is comparable to 45% in 1980, representing a significant increase in that staff category.

Average staff size was examined for each of the four size groups, and it was noted that public institutions generally report larger staff sizes than do private institutions of similar size. Average staff size is also related to institutional complexity, with universities reporting the largest, and two-year institutions reporting the smallest. Also, in most size groups, the separate administrative installations report a larger staff than the combined academic/administrative installations. This situation is undoubtedly due to the sharing of most of the staff resources in the combined installations.

Budgets

The annual budgets for administrative information systems are difficult to compare for many reasons explained in Chapter 4 of the monograph; however, the differences tend to average out when the data from a substantial number of similar institutions are aggregated.

The AIS annual budget reported by each responding institution was

divided by that institution's annual operating budget to determine a percentage for comparison. On this basis, almost three-fourths of the institutions are spending between 1% and 4% of their total operating budget on administrative computing. Only 5% of the institutions report an AIS budget that is less than 1% of the institution's budget; however, 24% report AIS budgets that are 4% of the institution's budget or greater. Twenty-eight percent of the public institutions are in this high range as compared to only 12% of the private institutions. Over half of the two-year institutions and the large institutions are in the 4% or more budget category.

While the amount spent on administrative information systems is of interest to many administrators, it should be recognized that expenditures measure only one *input* to the process; what is accomplished for the amount spent represents *output*, and both must be considered in any evaluation.

Institutional administrators should be interested in the percentage of the total institutional budget represented by administrative information systems expenditures; however, they should also monitor the amount spent on total administration each year. This point is explained in more detail in Chapter 4 of the monograph.

The distribution of the AIS budget by expenditure category is shifting dramatically from computer hardware to people. Since 1976, hardware costs have dropped from 45% to 28% of the budget while staff costs have risen from 35% to over 50%. This trend is likely to continue as computer hardware costs decline each year and staff costs rise at an increasing rate.

Computer Hardware and Communications

Using a distribution based on a simple count of computers listed by manufacturer, ten "leading" companies account for 87% of the computers listed on the 1980 Profile by 350 responding institutions. Forty-four other companies accounted for the other 13%. The information in Chapter 5 of the monograph indicates that IBM still leads the pack, accounting for 37% of the computers reported. Digital Equipment Corporation is second with 17%, and none of the eight other "leading" companies accounted for any more than 2% of the computers reported.

Chapter 5 of the monograph also contains bar charts that show the distribution of computers reported, both by the major institutional groups, and by the ten "leading" companies. This detailed information can be used to determine to what extent each company's computers are used by a specific institutional group; or, what institutional groups are using the computers from a specific company.

In the area of computer communications, 87% of all responding

institutions, and 97% of the large institutions, report the use of interactive computing. As could be expected, the average number of interactive devices is basically a function of institutional size; however, even the small institutions report an average of twenty interactive devices.

Remote-job-entry computing was reported by over half of the responding institutions, ranging from 75% of the large institutions to 22% of the small institutions. The average number of remote-job-entry sites also is a function of institutional size, ranging from seven for large institutions to one for small institutions.

Software

Proprietary Software. The use of proprietary software is clearly increasing in colleges and universities, so the 1980 Profile gathered data on which packages are in use. A cursory analysis of the 1,169 proprietary packages reported indicates that 10% are database or file management systems, 17% are application packages, and the remaining 73% fall into the "miscellaneous" category of utility programs, programming languages, statistical packages, text editors and similar packages. Detailed listings of the most often reported proprietary packages are included in Chapter 6 of the monograph.

Administrative Applications. The CAUSE National Database requested information on 144 administrative applications in eleven application areas. The eleven areas were chosen to be roughly equivalent to the appropriate sections of the NCHEMS Program Classification Structure,[4] and the 144 applications were based on the survey forms of the *Fourth Inventory of Computers in Higher Education 1976-77*[5] with several additions.

Almost eighteen thousand administrative applications were reported in production by the 350 responding institutions, with an average of fifty-one applications per institution. Private institutions more than tripled the number of applications since 1976, while public institutions experienced a 70% gain in the same time period. Large institutions reported an average of sixty-eight, while small institutions reported an average of thirty-three applications per institution.

As might be expected, admissions and records applications are the most frequently reported applications, with financial management second, and planning, management and institutional research third. The admissions and records and financial management areas account for 55% of all applications reported, and the other nine areas account for the remaining 45%. Physical plant applications are the least reported, accounting for only 2% of the total.

The percentage of administrative computing applications operating in an on-line mode has generally doubled since 1976 for all institutional

groups. On the 1980 Profile, two-year institutions and small institutions report the highest percentage of on-line applications in production (43% and 36%).

Administrative Computing Trends

Higher education is also following the trend in industry to treat information as a corporate resource, with an organizational unit serving as a "central focus for technology" reporting at the vice-president level. This office may have central coordinating responsibility for planning, record keeping, reference services, communications, administrative computing, and word processing. This central focus on information generally crosses traditional "data fiefdoms" that usually report to separate vice-presidents. Another key activity is the integration of planning information from the many institutional operational files and from external sources into a planning database with consistent longitudinal data. Even when these activities are the responsibility of a separate formal planning department, close coordination with and support of the administrative computing office is required.

As the planning database becomes established, some form of modeling generally follows, ranging from simple projection models using electronic worksheet software on microcomputers to full participation in the EDUCOM Financial Planning Model (EFPM) user community.

The trend in administrative computing hardware is toward a central facility for the corporate database, with mini-computers operating as transaction processors in the major administrative departments. This trend has some interesting side effects. In some cases, the budgets for operating these distributed processing centers, including personnel, are also distributed. In most cases, the central administrative computing unit acquires, installs and maintains the distributed computer and communications hardware and software; however, the professionals in the administrative department become far more involved in the daily system operations.

The explosion of word processors and desktop computers is also forcing a change in the administrative computing environment. The widespread existence of word processors that do desktop computing and communicate, and desktop computers that do word processing and communicate leads to a third tier in the administrative computing environment. These departmental and individual devices provide for a tremendous increase in professional productivity, allow greater access to the corporate database, and most importantly, provide the means for communication via electronic mail systems.

INSTRUCTIONAL COMPUTING

Instructional computing in colleges and universities can be divided into three major categories: (1) computer-aided instruction (CAI) and computer-managed instruction (CMI); (2) the use of computing in traditional instructional areas; and (3) the study of computing and information systems.

Computer Aided and Computer Managed Instruction

In the case of CAI and CMI, the computer is used to increase the productivity of either the instructor or the student, or both. Both CAI and CMI systems are currently in operation on maxi-computers supporting many work stations, and on single-person micro-computers. Computer software for CAI ranges from simple programs that teach elementary school children through computer games to packages that allow instructors to "author" courses with a minimum of computer expertise. Computer-managed instruction programs increase faculty productivity by assisting with many of the clerical tasks associated with the instructional process.

Instructional Computer Use

The widespread use of computers by students in almost every academic discipline has prompted a concern for computer literacy on many college and university campuses. Richard Van Horn, provost and senior vice president at Carnegie-Mellon University, defined four levels of computer literacy for students. Each of these levels involves institutional and departmental policy questions as well as resource implications:

- *Elective:* computing is viewed as an interesting subject that students can elect to study if they so wish.
- *Literacy:* computing is a basic area of knowledge and every student should understand the essentials.
- *Skill:* computing is viewed as a universal intellectual skill similar to natural languages or mathematics.
- *Foundation:* computing is recognized as the key technology for information processing and information processing is recognized as the fundamental process in learning.[6]

The appropriate level for any specific institution should be carefully determined by the appropriate institutional academic policy groups in accordance with the goals of the institution.

In addition to computer literacy, students on many campuses are also using computers for data analysis and retrieval of information from local and national databases. Many institutional computer centers are already allocating some resources for access to national

networks and national databases in addition to on-campus computing resources.

Currently many institutions are preparing for the transition to a technology based environment, and these activities are occurring none too soon. A student association at the University of Notre Dame recently discovered through a survey that over four hundred students had personal microcomputers on campus. Students are already preparing academic papers with word-processing packages, and in some cases without the knowledge of the instructor, who gives a significant portion of the student's grade on mechanics. The mechanics are, of course, perfect every time. Some institutions now provide electronic mailboxes for all students and faculty, and many more are considering such systems.

In an article in the *New York Times*, Richard Van Horn outlines a future scenario for "A Day With a Live-In Campus Computer"[7] where a student does homework that includes access to a census database and a bibliographic search, communicates with several friends and faculty members by electronic mail, and balances her checkbook by computer from her dormitory room.

The study of computing and information systems is one of the fastest growing academic areas in campuses all across the country. In addition to the acute shortage of computer professionals in industry, there is also a large gap between the number of trained professionals and the number of open positions at all degree levels. This shortage is particularly acute at the Ph.D. level, and is aggravated by the salary differential between industry and higher education. Institutions are rushing to expand course offerings in this technical area, but are hampered by the shortage of professionals to teach these courses. Many colleges and universities are forging new partnerships with local companies to provide resources and personnel to meet these new demands.

Research Computing

As administrative and instructional computing becomes more decentralized as a result of the microcomputer explosion, research computing appears to be going in two directions simultaneously. The ever-increasing capability of microcomputers provides many researchers with professional desktop computing and access to national networks and databases through communications. At the same time the number of large scale and super-scale problems that require mega-computers are increasing.

Simulation models of enormous size require the manipulation of huge databases in real-time. For example, the National Center for Atmospheric Research (NCAR) in Boulder, Colorado has a weather

model of the world that, when originally designed, required over fifty hours of computer time to predict forty-eight hours of weather. With NCAR's new super-computer this same model now runs in less than one hour. As our world becomes more technical, more and more problems require the super-computer solutions, and many of those problems are solved in the university research environment.

It is obvious that every university in the country cannot afford to maintain the mega-computers and the sophisticated software required to support a full range of research computing capabilities. The existence of national networks such as EDUNET can, however, make it economically possible for some institutions to specialize in providing certain computing solutions to researchers at many other institutions. The host institution serves an economically viable user base, and the other institutions can provide the needed research computing capacity to faculty members at a marginal cost rather than at a total cost.

SUMMARY

As stated by John W. McCredie, "The United States is fast becoming an information-based economy and computer technology is central to this movement."[8] The convergence of computing and communications technologies will enable organizations and professionals to cope with and adapt to this new environment.

Higher education institutions will not only benefit from the use of the new technologies, but will also be called upon to provide the educated professionals to sustain the movement. The demand for courses in computing and information systems as well as the increased use of computing in both instruction and research in all disciplines will create pressures for increased funding for both faculty and facilities in most institutions. Some institutions will view these waves of change as insurmountable problems, while others will consider them as challenges and opportunities. In either case, there can be no question that acceleration of technology will change the way all institutions operate.

Footnotes

[1] Charles R. Thomas, *Administrative Information Systems: The 1980 Profile* (Boulder, Colorado: CAUSE, 1981).

[2] Carolyn R. Smith and Geneva C. Davis, *Education Directory, Colleges & Universities 1980-81* (Washington, D.C.: National Center for Education Statistics, 1981).

[3] John W. Hamblen and Carolyn P. Landis, eds., *The Fourth Inventory of Computers in Higher Education: An Interpretive Report* (Boulder, Colorado: Westview Press, 1980), p. 33.

[4] Douglas J. Collier, *Program Classification Structure*, Technical Report 106, 2nd Edition (Boulder, Colorado: National Center for Higher Education Management Systems, 1978).

[5] John W. Hamblen and Thomas B. Baird, eds., *Fourth Inventory of Computers in Higher Education 1976-77* (Princeton, New Jersey: EDUCOM, 1979), p. XII—Form No. 4.

[6] Richard L. Van Horn, "How Much Computing Is Enough?", *Proceedings of the Eleventh Annual Seminar for Academic Computing Services*, Oregon State University, 1980.

[7] Richard L. Van Horn, "A Day With a Live-In Campus Computer," *The New York Times*, Section 12, 15, November 1981.

[8] John W. McCredie, "Campus Information Processing: A New Wave," *Educational Record*, pp. 6-11, Fall 1981.

4

MODELING AND SIMULATION

Daniel A. Updegrove

Daniel A. Updegrove is director of planning model activities at EDUCOM, a Princeton, New Jersey-based nonprofit organization of 325 colleges and universities. He has lectured and consulted widely on the design and application of computer-based models.

Despite widespread and frequently harsh criticism in the last decade, computer-based planning models for colleges and universities appear to be enjoying a resurgence. This resurgence is the result of the confluence of five factors: institutions' current need for improved decision making, the learning about the do's and don'ts of modeling that has taken place during this period, the widely publicized success of modeling at Stanford University, the improvement in modeling-system software, and, finally, the availability of new delivery systems.

About the demographic, economic, physical, and political problems facing colleges and university administrators, little need be said here. As documented annually by Halstead, and Minter and Bowen, monthly by the *Business Officer*, and weekly by *The Chronicle of Higher Education*, policy makers are faced with a plethora of trade-offs subject to both increasing resource constraints and increasing uncertainty. Although management science textbooks would characterize this as an ideal environment for modeling, so many modeling efforts have failed miserably that it is surprising to find the leadership of basically conservative institutions turning to models. Today's

---

N. Poulton (Ed.) *New Directions for Industrial Research: Evaluation of Management and Planning Systems*, No. 31. San Francisco: Jossey-Bass, September 1981.

models, however, are different from previous approaches — in conception, development, and use.

THE PROMISE AND PROBLEMS OF PLANNING MODELS

A model is a synthesis of known facts, theories, and judgments into a meaningful pattern that represents some real-world reference systems (Hopkins and Massy, 1981). The model is usually quantitative, with a set of user-specified inputs and assumptions ("exogenous" variables), a set of output results of interest ("endogenous" variables), and a set of equations or decision rules for generating outputs from inputs. Although it may be computerized to speed up the calculations (often with loss of control and clarity for anyone not skilled in computer manipulation), the model itself is nothing more than inputs, outputs, and equations.

Planning models of an organization have as exogenous variables both organizational policies and external factors. This makes them ideal for "what if" analyses: "What if inflation increases by a percentage point a year for the next three years?" or "What if we raise tuition by three hundred dollars?" or "What if we keep salaries even with inflation?" Although attention is usually focused on these planning variables, the validity of the model depends on the often-overlooked equations that determine the changes in the outputs as functions of the what-ifs. All too often, critical scrutiny of a model ceases when it produces a plausible "base scenario" (the result of the set of most likely inputs), whereas the real test of a model is how its outputs respond to changes in the planning variables. Once constructed, a model should be made to display a wide range of what-ifs at high speed and low cost. Some planning models are also programmed for goal seeking — for example, "What enrollment level would balance next year's budget?" — but rarely do they optimize in the sense of "What is the best student-faculty ratio, all things considered?"

Critiques of Packaged Planning Models. Most of the discussion of planning models in higher education has focused on the large packaged models for resource allocation and prediction, namely RRPM, CAMPUS, and SEARCH. In fact, a reader of volume nine in this series, *Assessing Computer-Based Systems Models* (Mason, 1976) would be led to believe that these three models and their European counterparts were the only extant models worthy of discussion. As is well known by now, these models are based on the "induced course load matrix," which displays courses taken by majors and offered by departments. If the data to construct such a matrix can be collected (often a heroic task), and if the matrix coefficients are stable from year to year (often a heoric assumption), the models can be used to

examine the impact of changes in enrollment patterns as well as program decisions on the instructional operation.

The expense of data collection, the technical support required to operate these models, and the lack of insight into noninstructional areas provided ample fodder for a number of critics (Hopkins, 1971; Plourde, 1976). In fact, similar large, rigid, data-intensive, and technically complex models met with similar criticism in the areas of national postsecondary education planning (Dresch, 1975), urban planning (Lee, 1973), and public policy analysis (Greenberger, Crenson, and Crissey, 1976).

Much of the blame for the ineffectiveness of models has been ascribed to the wide gulf between modelers and policy makers. Modelers tend to be trained in engineering, economics, and operations research, all fields well known for quantitative rigor and intolerance for the ambiguity and "irrationality" of organizational behavior. As Keen (1977) points out, operations researchers have sought increasingly sophisticated optimization models long after organization theorists like Herbert Simon (1957) observed that decision makers do not optimize, and political scientists like Charles Lindblom (1959) argued that they should not optimize. Thus, Schroeder (1977) states unequivocally: "The only good way to ensure that the focus stays on the larger goal (decision making) is to maintain user involvement. Administrators should be in charge of the systems design effort, not at its mercy" (p. 106).

Custom-Built Models. Schroeder's prescription for custom building policy models is especially appropriate if the administrator is also a systems designer. For instance, former Dartmouth President John G. Kemeny, a mathematician and computer scientist, built successful models for faculty appointment and promotion rates, assigning faculty billets to departments, program options for year-round operations, and endowment management (Kemeny, 1973). Bloomfield at Oregon State (1977), Strauss, Porter, and Zemsky (1979) at the University of Pennsylvania, and countless others have combined in one person, or one group, the dual talents of administrative and model-building skills.

Perhaps the best-known modeling team has been at Stanford University. There, Provost William Miller; Vice-president for Business and Finance William F. Massy; Senior Staff Associate, now assistant dean for administration of the medical center, David S. P. Hopkins; Associate Provost for Budget and Planning Raymond Bacchetti; and Research Assistant, now director of the American Council on Education (ACE) Financial Condition Project, Nathan Dickmeyer, produced a series of budget planning and faculty flow models that have been both successful at Stanford and widely publicized (Dickmeyer, Hopkins,

and Massy, 1978; Hopkins and Massy, 1981). It seems clear that modeling succeeded at Stanford because the models were developed in response to the need for solutions, the entire group of top budget officers was involved, and all models were kept small and simple. Often overlooked, however, is the team's expertise; among the members were Ph.D.s in computer science, economics, and operations research.

The Stanford modeling process could not be imitated easily, nor could the Stanford models be applied directly in other institutions, as was discovered by administrators at Harvard, Lehigh, Oberlin, the University of Pennsylvania, and the State University of New York (SUNY) at Albany. These five institutions participated in a feasibility study under EDUCOM auspices to determine the applicability of the Stanford models in other environments. In each case, the models had to be programmed to fit the data, organizations, and decision-making styles of the test sites before they could be useful. Moreover, in each case the model required the support of a key executive during its development and use (Wyatt, Emery, and Landis, 1979).

But what of institutions whose administrators are not systems designers? Either they have had to learn about programming languages, compilers, and the like, or they have had to rely upon computer center personnel or consultants (or perhaps the proverbial "gifted" student). Given the demands on their time, they usually delegate the project, only to learn that the staff are busy on payroll or affirmative action reports (or that gifted students have little patience for documentation). Is it any wonder that we find so many remnants of custom-built models, some that never worked and many that worked only when their designer (who has long since left) was at the controls?

A New Approach: Interactive Modeling Sequence. If packaged models do not allow for user involvement in their design, and custom-built models force the user into systems design as well as model design, a logical compromise is the so-called modeling system or modeling language, which provides a content-free structure within which users can custom build models. Such systems typically provide a matrix that holds data values, flexibility for the user to label the rows (variables) and columns (time periods), a format for specifying a set of equations (either in program subroutines or tables), and a convenient facility for changing the values of the planning variables and displaying the results.

Many people will recognize these as attributes of HELP/PLANTRAN, an early modeling system (Midwest Research Institute, 1972) that has been, unaccountably, characterized as a model in much of the literature (for example, Plourde, 1976). HELP/PLANTRAN was an innovation; its relative lack of acceptance can be attributed to two

factors: It was bucking the tide of the large resource allocation models, and it was a punch card batch-processed system. All such planning systems are now interactive, operated at terminals connected to time-shared computers or (more recently) to stand-alone microcomputers. Examples of currently available modeling systems include MAPSS (Planning Management Services Group, 1979), EMPIRE (Applied Data Research, Inc., 1978), VISICALC (Personal Software Inc., 1979), and the EDUCOM Financial Planning Model, EFPM (Jones, Merrill, and Orcutt, 1980).

EFPM: Uses and Users

EFPM, developed by EDUCOM with grant support from the Lilly Endowment, appears to be the most widely used modeling system in use in higher education. EFPM is based on the Stanford TRADES model and, like TRADES, enables users to display alternate forecasts, seek "feasible" policies (those that do not violate any user-defined constraints), and graph policy tradeoffs. The widespread use of EFPM is attributable in large measure to the delivery system chosen by EDUCOM. Rather than installing the software on local computers, EDUCOM has opted to make EFPM available over telephone networks to one host computer at Cornell University. Users thus avoid the delay and expense of local installation and maintenance while taking advantage of electronic communications to other users and the central consulting staff (Jones and Updegrove, 1978).

Since its public release in August 1978, over one hundred colleges and universities in the United States, Australia, Belgium, and Canada have subscribed to EFPM. Subscribers include large and small, public and private institutions, and applications are found in central administrations and subunits. Despite its origins in a private university, EFPM is used most extensively at Purdue, where applications include legislative budget requests, computer center indirect cost recovery, clerical and service wage parity, and financing of the student hospital, recreational gymnasium, and parking facilities. Since the content of the data matrix is not limited to financial categories, EFPM has also been used for student- and facility-flow models. Users of the system include chief business officers, chief academic officers, budget officers, institutional researchers and planners, faculty, and graduate assistants. Many of the users have no previous computer background (Bloomfield and Updegrove, 1981; Updegrove, 1981).

Impacts. In a recent survey, EFPM users were asked to indicate the significant benefits (if any) of their modeling application. Only a few reported that the model resulted in different decisions. For instance, the tuition rate at Carnegie-Mellon is apparently higher than it might have been because the tuition committee was persuaded through the

use of the model that a larger increase was needed to offset the assumed inflation rate (Knodle and others, 1979). What of the others? Although the system was rated highly by most users (over seventy-five percent reported that the time and money invested were justified, and over ninety percent of first-year users renewed their subscriptions), it seems clear that changed decisions per se are not perceived to be the critical impact of modeling.

The benefit most frequently cited was the ability to consider more alternatives. Related benefits cited frequently were more accurate analyses, more consistent assumptions, and more consideration of the future. These benefits fit the traditional concept of rational choice as cited by Hopkins and Massy (1981), namely, models increase the sense of intellectual control that administrators have over the institution.

The second most frequently cited benefit was "Building the model forced us to understand the nature and structure of our problems," followed closely by "We ask better questions." Such responses are consistent with what has become almost conventional wisdom about modeling, as noted by Keen (1977, p. 43): "The analytic perspective may thus be the most valuable . . . in clarifying existing knowledge." March (1971, p. 10) goes farther in arguing that "Human choice behavior is at least as much a process of discovering goals as for acting on them." Thus, many modelers have claimed success for models that never were run to completion because learning took place in the model construction process. Cynics have often pointed out that most of the learning was by the modeler, rather than by the decision maker. In the case of this survey, however, decision makers cited this benefit as often as modelers did.

Finally, many modelers responded, "We communicate better with each other." This also is a common claim for modeling, especially in higher education, with its high regard for mutual understanding. In particular, models appear to be able to communicate the financial dynamics of colleges and universities to faculty and students much better than financial statements.

Likely Future Trends. Three interconnected trends are now apparent: increased usage, increased need for communication, and improved delivery systems. After an institution or an individual has had a successful modeling experience, it is likely that other policy/problem areas will then be modeled. Examples include expanding a budget model to include fully detailed models of endowment income and student aid expense, as well as disaggregating a university budget model into its component colleges. As the number of models and modelers increase, so, too, does the need for automated model linkage, electronic mail, documentation standards, and the like. In addition, interinstitutional communication can be expected to

improve, as modelers seek both better models and comparative indicators of financial health (Updegrove, 1978).

As modeling becomes less of an exotic research and development activity and more of an administrative utility, pressures will build to increase response time, enhance graphic display capabilities, and provide access to administrative databases (Keen, 1980). Thus, the next generation of modeling systems can be expected to include microcomputer work-display stations linked to larger mainframe computers. The technology will provide more power at less cost. The key question will continue to be: "Is anyone better off?"

PRECONDITIONS FOR SUCCESSFUL MODELING

Because of the diversity of modeling system applications among a heterogenous group of colleges and universities, it is impossible to prescribe a set of procedures that will guarantee success. Several common themes do emerge, however, from the literature and the EFPM user survey.

Executive Commitment. First and foremost, there must be top-level commitment to the model. A similar requirement has been postulated for the success of management information systems by Wyatt and Zeckhauser (1975). It is not enough for an executive to authorize the acquisition of software or the commitment of staff. He or she must be willing to get intellectually involved in the construction and operation of the model. This does not mean that the executive must sit at the terminal; but it does mean that the substantive thrust, the choice of primary planning variables, the basic equations, and report formats must be understood.

The executive is usually a vice-president, although he or she may be the president in a small college. The actual computer terminal work is usually performed by a staff person reporting either to the executive or to an "interpreter," such as the director of institutional research. In some instances (Haverford, Oberlin, Swarthmore), the vice-president has done all the modeling work with no staff assistance.

As modeling proliferates within the institution, the same general rule applies: Each model must have its executive "godfather." The actual modeling is sometimes performed for all by a central modeling consultant (for example, Purdue), is sometimes decentralized (Stanford), and is sometimes performed by subunit staff with help from a central staff (Georgetown). Questions regarding the best forms of intermodel communication are too new to have ready answers.

It has been hypothesized that one other aspect of executive commitment is at work with modeling systems that require nontrivial institutional expenditures. EFPM out-of-pocket expenses for the first year average five thousand dollars, whereas RRPM can be purchased

for about one hundred dollars. Hence, vice-presidential (or presidential) approval was required to begin the modeling process. Consequently, the executive had to be convinced of its value before making the decision. The executive and his or her staff will thus have a much greater incentive to get their money's worth. EDUCOM staff speculates that had external funding permitted disseminating EFPM for free, the number of users would have been larger, but the proportion of successful applications would have been significantly lower.

Technical Considerations. Although much of the foregoing has been an argument for modeling as a process, there are some specific technical guidelines for building the model itself. First, the model should be as simple as possible without sacrificing completeness on important issues. Hopkins and Massy (1981) argued that if one cannot understand a model well enough to derive its results by hand, then its use for policy planning is probably irresponsible. Output formats must be familiar to decision makers: A finance committee used to seeing "student fee revenue" will be disoriented with results on "tuition income." Input formats and labels are only slightly less critical. For example, it is much better to have a variable named "Tuition" than one named "X(211y1)." Finally, the model should be adaptable to changing circumstances and conceptions of the problem. Because a new technical staff assistant is not likely to know which policies and problems to anticipate, even these technical guidelines argue for the inclusion of the executive in the modeling process.

MONITORING AND ASSESSING IMPACTS

Implicit in this survey is a set of criteria for monitoring the impacts of models. First, there is a set of objective criteria: Is the model finished? Is it comprehensible to key people? Is it used by planners and decision makers? Some criteria may be ambiguous. For instance, if the model's structure is changed frequently, it could mean that new insights are emerging, or that errors are being corrected (or both). It is a good sign if decision makers request new scenarios or entire new models.

It is usually difficult to determine that a decision has changed because of the model. It should be possible to observe that more alternatives are being considered, that more long-range implications are being considered, and that more fine tuning is being done. Improved understanding of problems should be apparent in discussions, debates, and questions, especially questions from previously uninvolved or naive parties.

Finally, there are some criteria for identifying unsuccessful modeling processes. If only one person in the institution understands the model, if all the debate focuses on the validity of specific assumptions

(for example, the inflation rate) rather than on the likely impacts of changes in the assumptions, or if there is no debate at all, then there is a serious problem. Perhaps the most pathological symptom is the statement, "The model made us do it" (Watkins, 1980). If the key people do not understand that the model is merely a tool for improving decision making rather than a substitute for decision making, then modeling will be a disaster.

Interactive modeling systems offer nontechnical administrators the ability to create adaptive models of their organizations. The model is not likely to be correct or useful, however, unless it is the result of a participatory modeling process headed by a key decision maker. As such, modeling can lead to optimality, but only if optimality is understood to be not a characteristic of the solution to the problem, but rather a process of adapting the organization to its environment.

References

Applied Data Research, Inc. *EMPIRE Modeling, Reporting, and Analysis System: An Introduction.* Princeton, N.J.: Applied Data Research, Inc., 1978.

Bloomfield, S. D. "Comprehensive Faculty Flow Analysis." In D. S. P. Hopkins and R. G. Schroeder (Eds.), *New Directions for Institutional Research: Applying Analytical Methods to Planning and Management*, no. 13. San Francisco: Jossey-Bass, 1977.

Bloomfield, S. D., and Updegrove, D. A. "An American Modeling System in Europe." *Journal of Institutional Management in Higher Education*, 1981, 5 (2).

Dickmeyer, N., Hopkins, D. S. P., and Massy, W. F. "TRADES: A Model for Interactive Financial Planning." *Business Officer*, 1978, *11* (9), 22-27.

Dresch, S. P. "A Critique of Planning Models for Postsecondary Education: Current Feasibility, Potential Relevance, and a Prospectus for Further Research." *Journal of Higher Education*, 1975, *et (1), 245-286.*

Greenberger, M., Crenson, M. A., and Crissey, B. L. *Models in the Policy Process.* New York: Russell Sage Foundation, 1976.

Hopkins, D. S. P. "On the Use of Large-Scale Simulation Models for University Planning." *Review of Educational Research*, 1971, *41* (5), 467-478.

Hopkins, D. S. P., and Massy, W. F. *Planning Models for Colleges and Universities.* Stanford, Calif.: Stanford University Press, 1981.

Jones, A. M., and Updegrove, D. A. "The EDUCOM Financial Planning Model: In Use Over EDUNET." Paper presented at CAUSE '78 National Conference, New Orleans, Dec. 1978.

Jones, A. M., Merrill, L. A., and Orcutt, R. L. *EFPM Documentation for Users.* Princeton, N.J.: EDUCOM, 1980.

Keen, P. G. W. "The Evolving Concept of Optimality." In M. K. Starr and M. Zeleny (Eds.), *Multi-Criteria Decision Making.* TIMS Studies in the Management Sciences, No. 6 New York: Elsevier North-Holland, 1977.

Keen, P. G. W. "Decision Support Systems: Translating Analytic Techniques into Useful Tools." *Sloan Management Review,* Spring 1980, *21* (2), 33-44.

Kemeny, J. G. "What Every College President Should Know About Mathematics." *The American Mathematical Monthly,* 1973, *80* (8), 899-901.

Knodle, L. L., and others. "EFPM: Users' Experiences at Purdue, Oberlin, and Carnegie-Mellon." *EDUCOM Bulletin,* Summer 1979, *14* (2), 5-11.

Lee, D. B. "Requiem for Large-Scale Models." *Journal of the American Institute of Planners,* 1973, *39* (3), 163-178.

Lindblom, C. E. "The Science of Muddling Through." *Public Administration Review,* 1959, 19, 79-88.

March, J. G. "The Technology of Foolishness." *Civilokomen,* 1971, *18* (4), 4-12.

Mason, T. R. (Ed.). *New Directions for Institutional Research: Assessing Computer-Based Systems Models,* no. 9. San Francisco: Jossey-Bass, 1976.

Midwest Research Institute. *PLANTRAN II: Computer-Based Institutional Research and Planning.* Kansas City, Mo.: Midwest Research Institute, 1972.

Personal Software Inc. *VISICALC Computer Software Program.* Sunnyvale, Calif.: Personal Software Inc., 1979.

Planning Management Services Group. *Management Analysis and Planning Support System User Manual.* Little Rock, Ark.: Planning Management Services Group, 1979.

Plourde, P. "Institutional Use of Models: Hope or Continued Frustration?" In T. R. Mason (Ed.), *New Directions for Institutional Research: Assessing Computer-Based Systems Models,* no. 9. San Francisco: Jossey-Bass, 1976.

Schroeder, R. G. "Management Systems Design: A Critical Approach." In D. S. P. Hopkins and R. G. Schroeder (Eds.), *New Directions for Institutional Research: Applying Analytical Methods to Planning and Management,* no. 13. San Francisco: Jossey-Bass, 1977.

Simon, H. A. "A Behavioral Model of Rational Choice." In H. A. Simon (Ed.), *Models of Man.* New York: Wiley, 1957.

Strauss, J. C., Porter, R., and Zemsky, R. "Modeling and Planning at the University of Pennsylvania." In J. Wyatt, J. Emery, and C. Landis (Eds.), *Financial Planning Models: Concepts and Case Studies in Colleges and Universities.* Princeton, N.J.: EDUCOM, 1979.

Updegrove, D. A. "The Potential of a Shared Modeling System for Measurement of Comparative Financial Conditions." Paper presented at ACE—NACUBO—NCES Working Conference on Measuring Financial Conditions of Colleges and Universities, Annapolis, Oct. 1978.

Updegrove, D. A. "EFPM: A Two-Year Progress Report." In *Planning for Computing: Proceedings of the 1980 EDUCOM National Conference. Princeton, N.J.: EDUCOM, 1981.*

Watkins, B. T. "How Stanford Uses Computer for Financial Modeling." *The Chronicle of Higher Education,* March 17, 1980, *20* (3), 3.

Wyatt, J. B., Emery, J. C., and Landis, C. P. (Eds.). *Financial Planning Models: Concepts and Case Studies in Colleges and Universities.* Princeton, N.J.: EDUCOM, 1979.

Wyatt, J. B., and Zeckhauser, S. H. "University Executives and Management Information: A Tenuous Relationship." *Educational Record,* 1975, *56* (3), 175-189.

5

THE AUTOMATED OFFICE

Samuel J. Kalow

Samuel J. Kalow is manager of Office Systems, IBM Corporation. He is a popular lecturer and author in the field of business and office technology.

While considering the office as a place to work, most would recognize that technology rarely has affected the office in the past.

What is the evolution and the purpose of the office system? What are the office's functions, and what are some of the interesting developments?

The major reason for any change in the office was productivity. Technology has affected the office only twice before in history. The Egyptian Pharoahs, Julius Caesar and Abraham Lincoln used office systems exactly the same way. No technology existed to help people use the office system after writing had been invented. If Abraham Lincoln needed a copy, somebody had to make a copy the same way someone did for Julius Caesar.

The technology that first affected the office was electricity. With the invention of the telephone in 1876, the office system changed and continued to change rapidly. In 1877 Edison invented the dictating machine. Herman Hollerith was working in the Census Bureau in 1880, and it took years to count the 1880 census data. He then invented punch card equipment which was used in the census of 1890, and it became the foundation of today's computing equipment. In 1868 Christopher Scholes invented the first typewriter. The first copying machine, whether you think of it as the mimeograph or photograph, was invented before the turn of the twentieth century as was the Burroughs Printing Adding Machine.

All the technology that we think of as office equipment was invented before the turn of the twentieth century. You could really make a case that electricity was the first technological change agent that affected the office.

It affected the office in more ways than just technology. For example, in *A Christmas Carol*, Bob Cratchit was an office worker. Men were office workers during the Victorian era. The introduction of the typewriter and the telephone resulted in women becoming the predominant office workers.

But then the office changed very little. If you visited an office in 1910, 1920, 1930, or 1940, you would see minimal technological changes. Office equipment then consisted of a typewriter, a telephone, an adding machine and a mimeograph. New technology arrived after World War II with the advent of magnetic recording.

THE MAGIC OF MAGNETIC RECORDING

Before World War II you could not buy a tape recorder or a wire recorder in a store. They were non-existent. In fact, the first commercial magnetic recording machine was sold in August 1945 in Macy's Department Store in New York City. It was a Pierce Wire Recorder.

With the available magnetism technology, the office system changed rapidly. A computer is really a punch card machine with a magnetic memory. We had the magnetic tape dictating machines, magnetic striped ledger cards, magnetic card, magnetic tape and magnetic diskette typewriters. This whole technology is a post-World War II phenomenon.

The technology that affects the office system today is broad-band communications and satellite communications. We have reached the point of diminishing returns in typing productivity. There are few ways to type any faster. The opportunity that we see now is the delivery of the typed information at high speed and low cost from one location to another. Think of the revolution that we are experiencing now to set up electronic document distribution (EDD) networks and document distribution networks within organizations and outside organizations. General Telephone and Electronics is setting up Tele Mail and Western Union is selling Mailgram. Communications costs are decreasing rapidly.

USING MULTIFUNCTION TERMINALS

The second major office system change is the use of multifunction terminals. Familiar data processing terminals are used to enter information into a computer to calculate data and review information

on a data base. That type of terminal uses a typewriter keyboard. It has a QWERTY keyboard, QWERTY for the first letters of the first row of the typewriter. But it really is not used for typing. It does not have upper and lower case characteristics, and it does not have all of the symbols and tabs that are required in typing. New equipment has the aspect of being multifunctional machines that can be used for typing, for data processing, and for electronic document distribution. A Telex machine or a Teletypewriter allows electronic document distribution. It, too, uses a familiar typewriter keyboard. But most people do not use it to send correspondence. They use it for order entry messages, bulletin board notices, or confirmation entries, not the normal, routine office work.

OTHER APPLICATIONS

Another approaching change is referred to as administrative or non-typing applications. As people put more intelligence, more microprocessor capabilities under the covers of multifunction typing devices, they can program these devices to do calendaring, scheduling, and telephone answering. A lot of different administrative work occurs other than typing.

Electronic document distribution (EDD) seems to be the opportunity to change the office system. At a multilocation organization, information must come from the organization's various divisions and plants.

With electronic document distribution comes the opportunity to use a communicating typewriter, a typewriter that can communicate over telecommunication lines. The value is not only to transmit a typical page of typed documentation in about six to ten seconds, but when the information is received at your location, your secretary has a magnetic card, a floppy disk or a computer representation of that typing which can be used for revisions. There is a lot of interest in being able to transmit information quickly and inexpensively from one location to another.

FACSIMILE

The second kind of electronic distribution is facsimile which sends the entire page, the entire document, from one location to another. With this system, charts, graphs, handwritten information, etc., can be sent. New systems encode the information digitally, sending a page of information in about twenty to thirty seconds. The same page of information when sent by character-encoded electronic mail goes in six to ten seconds over voice grade telephone lines.

SPEECH FILING

The third kind of EDD is new, and was reported in *Business Week*. We have a publicized research project at our laboratories in Yorktown Heights referred to as speech filing. After calling somebody, and finding that person is out, you can leave a recorded message. It is not speech recognition, nor is it a system that recognizes the voice and types messages; it just records the voice and stores it for later listening. This technology is feasible because the digital storage cost is decreasing very rapidly.

FILING WITHIN THE ELECTRONIC SYSTEM

In the office system, not only do you have to create information and transmit it, but you want to file information. The office is a repository of history in the sense of filing, and within the electronic office system is an opportunity for personal files. An eight-inch wide floppy disc retains up to one million characters of information. You can now keep information in electronic form in your own office where you can retrieve it and refer to it at any time without storing a lot of paper.

When you set up electronic filing systems, you must recognize that in addition to your own departmental files and individual files, you must be able to store outside information. If you cannot store it electronically, what you can do is enter the parameters of the outside document into the system and then use electronic filing to sort.

PERSONAL PROCESSING

Another office system area is personal processing. More and more principals are willing to use terminals although it was previously anathema for a manager to type. Today there just are too few secretaries available even if the organization wanted to rely totally on clerical help. The *Los Angeles Times* classifieds include more ads for secretaries, typists, clerk typists and stenographers than for any other job category. On the other hand, more and more people are using terminals to do personal computing and to search data bases. Because the terminal has a typewriter keyboard, many people will use terminals to create text. The opportunity is to use a terminal for text creation and revision and to receive and transmit electronic documents. Also, you can reach into the electronic filing system for administrative applications — calendering and scheduling. The same device is used for personal computing.

There are many people today with personal computers who want to use the system this way. They want to use a computer for their own business purposes as well as to connect to the main computer of their organization. The willingness to personally use a terminal is growing very rapidly.

Project and task management is an example of how I use the system. We can use a system to sort, select and sequence information without asking anybody to program the computer. If I have people in my department doing different projects, I am able to keep that information on a list, and at any time I can ask for a printout. If I want to find out who on my staff has taught management schools, I can pull that information from the system. These office systems machines have records processing capability built right in.

PRODUCTIVITY AND THE OFFICE SYSTEM

President Ronald Reagan has spoken about productivity. I do not have to dwell on it. But it is certainly a key issue in the fact that we are experiencing inflation and high unemployment at the same time. From a national standpoint, you can see that productivity went up pretty constantly at 3.2 percent a year during the 1950s and 1960s. Everybody expected that productivity would continue to rise during the 1970s. In fact, productivity fell off, and in 1980, productivity was less than it was the year before.

This means that there are fewer real goods and services to go around. If you compare our country with other countries, you see that the rate of productivity in Germany and in Japan is increasing faster than in the United States.

INCREASING PRODUCTIVITY

In the United States, fifty-three percent of employed people work in an office, according to the Bureau of Labor Statistics. Anybody in the teaching profession can see many people working in an office. If you visit a plant, however, you would find twelve hundred people in manufacturing positions and thirty-two hundred people in the office.

Go to an oil company, and you will find that two-thirds of the people work in an office.

That is what has happened over the years. To increase productivity, we must say more to the factory worker than, "You have to work faster and smarter." You must say more to the sales representatives than, "You have to sell more quota in your time." You must say more to the service representatives than, "You have to fix twenty typewriters a day instead of eighteen typewriters a day." We must address the fifty-three percent of the people who work in the office. Office systems can start to address that group.

AUTOMATING FOR THE PRINCIPALS

IBM has discovered that people spend about half their time in meetings, a quarter of their time dealing in documentation, and a

quarter of their time dealing in administrative work. They think office automation could save fifteen percent of their time. So what do we do?

WHAT IS AN OFFICE SYSTEM SUPPOSED TO DO?

What is the purpose of an office system? Those in education might find this concept more difficult than people employed by an organization that deals with direct economic results. If we ask ourselves why we work in the first place, we answer that we work for food and for clothing and for shelter. Once we get those items, then we work for educational services, for recreational services, for insurance services, for medical services and so forth. And once we attain those, theoretically we work for self-actualization. Nobody works to have an office. Nobody really wants an office system as part of his or her operation.

ACQUIRING INFORMATION

The office's purpose is to deal with information. No organization would have an office unless it wanted more information.

What are we dealing with in the office? Acquiring information. You are acquiring some information right now, I hope. When you go to your office, you may dictate a memo, you may write a report, you may "originate" some information. Very little information is typed "for the file." Every once in a while you will send a memo to the file. Most information, however, is created for somebody else to read it. So you must distribute it. You may distribute it physically — you may make copies and distribute it. You may do it electronically. You may do it through the mail system. Nevertheless, information gets distributed.

Information gets filed. Why do we file information? Because if somebody does not have certain data, they have to relive the situation. We must proceed through the whole process of uncovering information. That is why we file information.

INFORMATION FORMAT AND OUTPUT

Format and output are part of the office system. The quality of print and layout contributes to the information transfer. Personal services in the office are valuable, such as telephone answering when you are away from your office, or having someone go through your mail for you.

We handle mostly written and visual information in the office, such as text, data, graphics, graphs, charts, and pictures. Voice is a major component because use of the telephone and meetings are such big parts of the office system. If you worked for the International Flavors

and Fragrances Company, you would find that smell is part of the office system. If you were to visit General Foods, you would find that taste is part of the office system. Go to Burlington Fabrics; you will find that touching "the hand" of the fabric is a requirement. Most people deal with just two senses in office systems — sight and sound.

NOT AS MUCH REDUNDANCY

In the merger of word processing and data processing, we find many opportunities to save redundant work. People have a lot of information stored in their computer files. They can use that material with the word processing system and save a lot of work. For example, to send letters to applicants, give the secretaries a listing from the computer. Even though they use an automatic typewriter and form letter, they still type the variables from the computer listing. Now we can transmit the information from the computer listing directly to an office systems machine. This information will merge the variable information with the fixed information and create the letters without anyone having to re-keyboard information. You can save a lot of keystrokes by merging these two systems.

EDUCATION AND TRAINING

The last point covers education and training. You must not only provide the system technology, but teach people how to use the system.

Implementing the system without educating the people to take advantage of it does not seem productive. If someone is promoted to a first-line manager, there is no guarantee that he or she knows how to train a secretary to keep the calendar. If the person does not know how to train the secretary to keep a calendar, giving the employee an electronic calendar may not provide much productivity. You must educate people about how the system works, what the benefits are and how they are to be used. What is electronic document distribution? What does it mean? How can you do it? We need to train secretarial management. We have to educate the secretary.

The office system we will see in the next five years will be driven by electronic document distribution and afford the opportunity for electronic filing and retrieval. The office system will merge the word processing and data processing systems and use the benefits of both to obtain the highest level of productivity.

6

PLANNING FOR INTEGRATED CAMPUS INFORMATION SYSTEMS

John W. McCredie

John W. McCredie is president of EDUCOM, a non-profit consortium of over 350 colleges and universities founded in 1964 to promote the use of computing, communications and information technology in higher education. He is editor of Campus Computing Strategies *published in 1983 by Digital Press.*

During the 1981-82 academic year, EDUCOM coordinated a study of strategic planning for information processing activities at ten colleges and universities. The goal of this project was different from several recent surveys analyzing hardware and software installed on many campuses. The study differed also from commercial marketing research that concentrates on procurement plans of different market sectors for terminals, processors, or communications equipment. Instead of examining campus hardware, software, or budgets, the EDUCOM effort concentrated on ideas, goals, objectives, and plans — the underlying strategies that shape the various implementation decisions.

EDUCOM decided to undertake this study because most colleges and universities are not organizing to take advantage of converging technologies such as: computing, high speed local and satellite digital communication, videodisc and other large capacity information storage devices, graphics, text processing, two-way cable systems, and artificial intelligence applications. Yet the challenges presented by these opportunities are just as great as the severe problems posed by demographic changes that are reducing the number of eighteen-year-olds available to enter college, and by the political changes altering the financial base upon which much of higher education is built.

Structured as a set of case studies and a small set of comparative data, the study did not try to be statistically significant. The ten participating colleges and universities do not represent typical institutions. They are a non-random selection from the subset of innovative schools actively planning to confront the information revolution sweeping both higher education and society in general.

The results of the project were published late in 1982 by Digital Press of Bedford, Massachusetts. In this book, *Campus Computing Strategies*, individuals directly involved in the planning process describe the information processing planning activities occurring on their ten campuses. The authors are not unbiased scholars; they are computing professionals. Clearly they see the world in general, and higher education in particular, from a different vantage point than the typical student, faculty member, or administrator. Therefore, the case studies present a view of each campus that is very different from most descriptions. Taken together, the cases present an interesting image of traditional academic institutions struggling with a technology that many people believe will cause waves of change comparable to the development of movable type in the fifteenth century. In addition to some unique ideas, several common technological assumptions and approaches to planning emerge from an analysis of the different approaches.

Although the case studies cover a wide range of different kinds of institutions (small liberal arts, large state universities, independent doctoral granting, church affiliated, and technological), there was no attempt in the selection process to be comprehensive in scope. The prerequisites for participation in the project were (a) an innovative campus approach to information processing, and (b) a willingness to describe the internal planning processes used by the organization. The participating institutions are:

- California State University System
- Carnegie-Mellon University
- Cornell University
- Dartmouth College
- Hamilton College
- University of Iowa
- University of Minnesota
- Pepperdine University
- Rensselaer Polytechnic Institute
- Stanford University

This article presents several of the important features of the ten case studies. The first section outlines the underlying planning assumptions common to the participating institutions. Then several characteristics of the different planning processes are described. The article con-

cludes with a brief discussion of some of the important similarities of the different strategies.

Several underlying assumptions are accepted by key individuals on each of the campuses involved in the project. These important hypotheses shape the plans and strategies that are evolving in each institution. Although there has been no formal survey to determine the extent to which these basic ideas are incorporated in planning on each campus, they appear in different ways throughout the formal and informal descriptions of individual plans. In addition, they are discussed at length during a meeting of the project participants. Common assumptions are:

- Creation, storage, retrieval, processing, use, and dissemination of information are the core of academic effort, and computer-based information processing activities are central to this effort.
- Information processing technology is fundamentally different, particularly in the academic environment, from other technologies. The ability of computing systems to process abstract symbols enables computers to be interactive participants, rather than passive tools, in teaching and research activities. Advanced systems available today are helping scholars discover new knowledge in addition to communicating information and processing data.
- The academic tradition is often viewed as antagonistic to strategic planning. However, since information processing activities span several disciplines, are expensive, and have such a potentially central role in higher education, planning for them is an important institutional activity in which leading faculty and administrators must be involved.
- The costs of computer hardware capable of performing at a specified level will continue to decline during the next ten years, as they have for the last thirty, at a compound yearly rate of about twenty-five percent. However, institutions in higher education must be prepared to make large incremental capital investments if they are to participate in, and contribute to, the movement of the United States to an information based economy.
- Regardless of their area of expertise, faculty, students, and administrators should have opportunities to learn about the capabilities of modern information processing systems.
- The convergence of computing and communications technologies will cause academic departments that have not had much in common in the past to work together closely in the near future (e.g., libraries, computing centers, telephone offices, printing departments, audiovisual support services, campus mail, etc.).

- Most successful uses of computing systems to date have concentrated on the processing of numeric data to support scientific and administrative activities. Since most of the work in colleges and universities deals with words and images, not numbers, the greatest future growth in computing will be the support of individuals who have not been the traditional community of computer users.

The extent and the kinds of planning in a college or university are reflections of both its academic character and management style. Planning procedures, to work effectively, should be consistent with the general management structure. Therefore, it is not surprising that several different planning styles were evident in the ten organizations involved in EDUCOM's study. Major differences appear to depend on (a) the type and length of an institution's involvement with computing, and (b) the size of the organization. Technologically mature institutions are more evolutionary in their approaches than those moving rapidly into a computer intensive environment from a non-technical base. Schools in the first category strive for more consensus about information processing future directions than those in the second. In the latter group, high-level advocacy seems to be more important.

Given the diversity of institutional management styles, it is surprising that several features are common to most of the planning processes described in the study. For example, all institutions in the sample have used task forces to get suggestions from several diverse constituencies within the institutions.

Stanford University has been deeply involved with computing since the 1950s. President Donald Kennedy describes Stanford's planning in the following terms:

> "It is especially important to emphasize . . . that plans are not necessarily centrally determined and imposed programs for institutional action. Indeed, in our circumstances the most appropriate model will not be a plan in the sense of a blueprint — the complete set of explicit instructions for assembling something — but rather a set of principles and conditions that promote self-assembly through the encouragement and decentralized initiative."

Within this environment, a large task force, formed in 1977, studied the future of Stanford computing and produced important reports in four major areas: text processing, database technology, networking, and large scale computing. Since publication of their findings, there has been no formal, centralized response to all areas. Instead, there have been projects — initiated by different departments — that are consistent with the principles outlined in the reports.

Carnegie-Mellon, Cornell, and Dartmouth all have computer planning processes that are similar to Stanford's. All four have a single administrative focal point (at the vice provost level) for coordinating the development of information processing facilities to support instruction, research, and administration. Each has, or at one time had, an active task force at work to define the future role of information technology on campus. All four have mature, well-developed computing operations; three have outstanding computer science research departments (at Dartmouth, computer science programs occur in four academic areas rather than in a single department); and all have strong high level administrative support. Stanford's task force issued its formal report early in 1980; Carnegie-Mellon recently completed its report; and the Cornell and Dartmouth committees are still at work.

On some campuses periods of rapid change lead to more formally structured approaches to planning and management. For example, in the fall of 1969, Pepperdine University's only available computing access was through a dial-up terminal located in a closet. Today the university has moved its main campus to a new location and enrolls three times the number of students it did in the 1960s. It now has a strong central computing facility and an approved five-year plan to implement an on-line decision support system. Academic computing laboratories provide both stand-alone microcomputer support and terminal access to the central facility. Pepperdine President, Howard White, recently stated:

> ". . . it is evident that the wave of the future demands that all students graduating from Pepperdine University become literate in the usage of information technology. Students should understand computing, word processing, communication devices and the integration of these to the extent that they can use this technology to solve problems, thus enabling them to compete in and contribute to the world in which we live.
>
> I am therefore appointing a small Strategic Planning Task Force to provide the administration with recommendations as to how best to accomplish this institutional goal by 1984 . . . The Task Force will solicit input from faculty, students, staff, administrators and industry leaders."

To manage and plan in a period of such rapid change, Pepperdine has created a complex formal structure of committees that participate in setting goals and provide controls and feedback to management. The university has published a mission statement, and computer services, like all major administration units, has a supporting set of goals and objectives to which annual budget requests must be tied.

Rensselaer Polytechnic Institute has also had a major computing metamorphosis taking place on campus since the mid 1970s. Until 1974, support for computation was provided by a small central computer that delivered modest batch processing service. When George M. Low became RPI's new president in the summer of 1976, he immediately formed and participated in a task force to study future computing needs. In May 1977, the RPI Board of Trustees made an important strategic decision: RPI should move into an academic leadership role in the application of computing and communications technology to the social, instructional, research, and administrative needs of the university and of the greater society of which it is a part. Now virtually all of RPI's 5,000 students use interactive computing facilities as a routine part of all professional degree programs.

To guide such dramatic change, RPI has developed three formal documents integral to its long-range planning process. The first, called "Rensselaer 2000," is the Institute's overall long-range plan for development by the year 2000. The second document specifies RPI's specific objectives for computing and information technology in support of the broad goals of "Rensselaer 2000." It has been approved by the provost as the description of the general framework for RPI's future information technology environment. The third document, the formal five-year plan, describes the short-range tactics and enhancements scheduled by the department of computing activities.

At Hamilton College, a small liberal arts school that has been involved with computing for approximately ten years, strategic planning is centered in the president's cabinet; no separate planning office exists. A presidential committee, in the early 1970s, recommended a future course for computing based on an understanding that (a) high quality computing resources are important to attract excellent faculty and students; (b) administratively the college needed better computer support; and (c) the best approach for Hamilton was to develop a special association with a computer intensive university (Cornell) in order to keep pace with the latest technological changes. Because it is small, an informal planning approach for computing works well. The director of the computer center is responsible for both academic and administrative computing. He meets informally with interested members of the entire Hamilton community to discuss plans and receive suggestions for service improvements.

Iowa, Minnesota, and the California State University system have computer planning processes that are different from the other seven institutions because they are large state universities. All three are involved with state boards, committees, agencies, and regulations. On these campuses there are several different types of planning processes at work concurrently.

Iowa is relatively decentralized and its planning reflects this organizational structure. At the heart of the process is a formal review system that begins with departmental self-studies and external review committees. Departments, colleges, and support units are reviewed every five years, but their plans are revised every year with formal reports sent to the Board of Regents every two years.

Planning for computing at Iowa is basically the same as planning for other resources and may be characterized as "bottom-up" rather than "top-down." There has been no university-wide committee on technology planning, and different departments have very different information processing goals. In the late 1970s, a committee recommended the continued separation of computing facilities, and the creation of a university-wide coordinating position. Although a formal search was conducted, this position remained open. The university hospital, administrative data processing, and academic computing have different long-range planning styles. In August 1981, the director of academic computing was appointed to a one-year term as special assistant to the president for Communication and Information Planning.

The state of Minnesota conducted a statewide study of information systems in all publicly supported institutions in 1969 and 1970. This study provided a strategic planning framework for development of educational and administrative computing throughout the state. One of the goals set forth in the study was for Minnesota post-secondary students to have access to approximately the level of computing recommended in 1967 by the president's Science Advisory Committee as a necessary and desirable level. The 1970 study presented several strategic objectives, and growth in computing at the University of Minnesota has proceeded within this framework.

The participants in the study from Minnesota identified three levels of planning for computing, communications, and information services that are occurring simultaneously — tactical, intermediate-range, and strategic. They believe all three should occur concurrently or else two undesirable outcomes could take place: (a) a "freeze" on new procurements and developments while everyone waits for the "final plan"; or (b) no coordination of actions because there is no broad framework in which short range decisions can be evaluated. Tactical planning includes replacement of large central computers and support for microcomputers and text processors. Intermediate range issues include items such as the replacement of the telephone system and continued automation of library operations. Strategic planning should include selecting the desired information environment, determining funding and organizational structures, and setting major operating policies. The basic mechanism used by the university to

address these issues is similar to the formal planning processes used by other participants in the project — a high-level, representative committee. The committee is making its final report in spring 1982, and decisions regarding its recommendations will be made at the highest policy level of the university.

The California State University enrolls over three hundred thousand students on its nineteen campuses. Coordinating the planning and operational management of information technology in this complex system is very difficult. An important goal of the present organizational structure is "to have in place policy and management mechanisms which optimize the commonality of information technology needs across campuses, while recognizing the distinctive characteristics and special needs of individual campuses. Likewise, each campus must have policies and mechanisms in place to optimize the mission of the campus while recognizing the uniqueness of the various academic schools and departments."

The system just completed installing new mainframes on seventeen of the nineteen campuses, and the remaining two are scheduled in the next year. These computers, coupled with existing local time-sharing systems, are connected by a statewide data communications system. This configuration forms the basis for a solid information processing utility for the CSU system. The system is moving in the direction of a totally integrated network. Planning foci include: developing local campus communications utilities, establishing an appropriate intercampus network with gateways to national networks, deciding on the appropriate uses for each campus' major computers, establishing standards for the use of microcomputers, defining the proper balance between administrative and instructional uses, and forecasting the proper amount of peripheral equipment for each campus.

Although the ten colleges and universities participating in the EDUCOM study differ substantially, there are important common denominators to their information processing strategies for the 1980s.

- *Organizational Structure* — Seven of the institutions have a single administrative office or individual to coordinate information processing related issues. Of the remaining three, two are actively considering the creation of such positions.
- *Decentralization* — All of the organizations are moving to a more decentralized information processing environment. This trend does not necessarily imply that centralized facilities will cease to exist, or even get smaller. It does mean that an increasing amount of information processing activity will occur outside of a centralized facility. The Dartmouth report states:

> "The problem is how to combine centralization with decentralization at a time of rapid change. This would be difficult even starting with a clean slate. In practice, however, Dartmouth has to move steadily, without interruption of service, from the present highly centralized structure without knowing the destination it is moving towards."

- *Personal Computers* — All of the organizations have, or are formulating, plans related to the growing potential of personal workstations for students, scholars, and administrators. Rather than resisting the avalanche of these systems (the way many organizations resisted minicomputers in the early 1970s) the ten campuses are actively encouraging innovative uses of personal computing systems.
- *Networking* — All ten campuses are involved with local and national networking activities. They are investigating, and a few have installed, experimental, high-capacity, digital local area networks. Some are even designing their own networks. Five of the universities have facilities connected to national packet switched networks, and all use such networks to share remote hardware and/or software resources. Several of the larger organizations are studying combined voice, digital, and video networks. Many face major investments in the telephone area, and are seeking to make such investments serve more than one purpose.
- *Library Automation* — Once again, all of the schools have plans to deal with the convergence of computing and communications to help provide access to library resources. Many project participants are using local computer systems for circulation and serials control. Several are using national networks and resource sharing organizations for cataloging, bibliographic, and inter-library loan services. Stanford's task force on libraries proposed a major transition: "from an emphasis on collecting and storage to an emphasis on selecting and sharing."
- *Information Processing Literacy* — Groups or task forces in each of the colleges and universities are studying what level of literacy about computing and communications activities is required of a well-educated graduate in the 1980s. This definition will vary for each institution, but all are working on the problem. For example, the Carnegie-Mellon task force reports: "For the next five years, we expect the major potential impact of computing will be to increase the effectiveness of student efforts outside the classroom."

- *Text Processing* — In all ten institutions, text processing services are seen as important to academic computer literacy and to administrative support. In fact, text processing is the most important service that can be provided to many humanities faculty and students whose work deals with words, not numbers.
- *Electronic Mail* — Several of the campuses have extensive electronic mail systems currently in operation, and most are actively considering how to provide this service in the future. Today these systems are used locally to allow convenient communications among faculty, students, and administrators. Many individuals are also using national computer-based mail systems for task forces to reduce travel costs and increase the effectiveness of communications.

Each of the ten colleges and universities is in the midst of a major evaluation of how it should participate in the information processing revolution taking place throughout modern society. Some of the strategies propose a position of leadership, while others suggest that a competitive stance with respect to peer institutions is reasonable. About half of the institutions have decided which strategy will be followed and have determined the broad outline of how it will be implemented. The remaining organizations are still creating strategies.

In all of the case studies, the word "plan" is not really appropriate. A better term is "planning process" because of the dynamic nature of the activities and the topic. Given the present higher education financial environment and the conservative nature of most colleges and universities, the process is much more complicated than seeking a consensus and implementing a simple plan. A fundamental property of the exciting concepts proposed in these case studies is that large financial and human resources are required to make the ideas come alive. A combination of new resources and a reallocation of existing resources is implied by these strategies.

There have been some negative, as well as positive, reactions to the planning activities on the campuses. An inherent danger to long-range planning, in general, is that some expectations may be raised to unattainable levels. In addition, there is often a backlash effect when major new ideas are proposed in organizations because existing subgroups try to protect their positions. The fact that such reactions are occurring on some of the participating campuses does not mean that the strategies are poor or that they will not be adopted. It does imply that these planning activities are being taken very seriously, and it reinforces the assertion that information processing strategies are crucial for the futures of colleges and universities.

7

DATA BASE MANAGEMENT SYSTEMS

John W. McCredie

John W. McCredie is president of EDUCOM, a non-profit consortium of over 350 colleges and universities founded in 1964 to promote the use of computing, communications and information technology in higher education. He is editor of Campus Computing Strategies *published in 1983 by Digital Press.*

INTRODUCTION

This paper describes the basic concepts of database management systems (DBMS), presents several features that should be compared when one is selected, and indicates some ways administrators can use microcomputer-based DBMS in their own departments whether or not a central DBMS is available. Even managers whose primary activities are not concerned with data processing should be knowledgeable about at least three major computer applications—text processing, financial planning and budgeting, and database management systems. Other applications are certainly important, but versions of these three are likely to appear in most office environments in the near future, if they are not already present.

The remarkable decline in costs of computer hardware during the last thirty years is one of the primary causes of the rapid proliferation of information processing systems throughout higher education and society in general. Currently an expenditure of a few thousand dollars can bring into a department, or home, a computer that would have cost hundreds of thousands of dollars several years ago. This rapid change in hardware economics is causing a revolution in the types of computer applications commonly performed directly by managers in their local environments.

Although most historical computer applications dealt with large scale numerical calculations of either a scientific or commercial nature, there is now a tremendous growth in the processing of textual information. Since professionals in higher education spend a significant portion of their working day dealing with text, it is not surprising that computers are now being used to aid in these efforts. The great popularity of word processing systems is the most obvious indicator of this trend. These systems help people to produce attractive documents and letters quickly, but there are sophisticated uses of such systems that are even more useful than editing and formatting. Many current programs locate spelling mistakes and indicate the use of jargon; others check for simple grammatical errors and give information about sentence and paragraph length; and still others provide statistics about the overuse of certain works in addition to stylistic indicators about the general readability of a document.

Most managers deal frequently with budgeting and longer-range financial planning issues. Current expenditures must be monitored and compared to budget, and financial plans for future programmatic changes should be part of any meaningful planning effort. Accounting and budgeting systems have traditionally been part of a centralized data processing department in colleges and universities, and often a manager had little direct involvement with the supporting computer systems. The recent availability of good financial modeling systems that are directly usable by managers throughout an organization has changed the way many of them plan their future programs.

Creating text and analyzing financial data are only part of the information handling tasks of managers. Before they can write about something or prepare a meaningful plan, administrators must assemble many data elements that are usually not readily available. Often they must retrieve specific facts and documents from large manual filing systems, and generate information from several different collections of data that are located throughout the organization, stored in different formats, controlled by different managers, and often not in machine readable form. Database management systems enhance individuals' ability to store, retrieve, and process numeric and textual information in flexible ways that were not necessarily planned when data were originally generated. A DBMS can be viewed as a unifying structure that holds part of an institution's management information together and makes it usable by, and valuable to, a wide variety of managers throughout the organization. A well-designed DBMS can be a very valuable management resource in a department, college, or university.

BASIC DBMS CONCEPTS

To put database management systems in a broader context, it is useful to think of them as part of a management structure usually called a management information system (MIS). James Emery, of the University of Pennsylvania's Wharton School, has used the following definition of an MIS in his decision sciences courses:

> A management information system is a set of formalized procedures for collecting, transmitting, storing, retrieving, and transforming information for the purpose of aiding humans to operate an organization and direct its behavior toward desired goals.

Notice that this definition does not include the word "computer." The question of which parts of an MIS would be computer-based is mostly an economic one. For example, it is hard to visualize a nation-wide airline, car, or hotel reservation system working without extensive computer support. Unfortunately, it is not difficult to find several examples of elaborate automated management information systems that have not worked well. Computers are not required in many situations and success is certainly not guaranteed just by deciding to use computers in an MIS. Administrators should learn enough about available computer support systems to exercise good judgment in the process of evaluating which, and how many, of an organization's functions should become part of a database system.

The terms "database" and "DBMS" have evolved over the years and they mean different things to different people. In this paper the terms will be used in the following ways:

> A database is the computerized collection of stored operational data files used by members of an organization to accomplish their job functions. It is a repository of computerized facts, figures, and documents accessible to authorized users. A database management system (DBMS) is the set of computer software that handles all access (retrievals, storages, modifications, and deletions) to the database.

Although computers are not necessarily central to the concept of an MIS, they are basic to the conventional meanings of databases and DBMS. A major computer development of the last fifteen years is the wide acceptance of products that enable various databases in an organization to be integrated into a broad conceptual model that can be managed by an organization-wide DBMS. The decision of which DBMS will be used, if any, is a major policy issue for any organization. Such decisions should receive the attention of managers at all levels.

In *An Introduction to Database Systems*[1], C. J. Date cites the

following reasons why an institution should choose to store its operational data in an integrated database that is centrally controlled:

- Redundancy in stored data can be reduced.
- Inconsistency in stored data can be minimized.
- Centrally stored data can be shared.
- Standards can be enforced.
- Security restrictions can be applied.
- Data integrity can be maintained.
- Conflicting requirements can be balanced.
- Data may be stored in ways that are independent of particular applications.
- Physical storage media, or access strategies, may be changed and updated without the necessity of modifying existing applications.

There are currently three major conceptual models commonly used by DBMS to represent data entities and associations among entities:

- the relational approach
- the hierarchical (or tree structure) approach, and
- the network approach.

In the relational model data are stored in simple two dimensional tables often called flat files, or relations. This model for data is very easy for users to work with because the concept of a table (where the rows represent different items and the columns represent attributes of these items) is so intuitive. Often the items in various tables are sorted on a primary key (such as student or employee name). All information in the database is represented in the same simple uniform manner. A major strength of the relational model is that its simplicity is accompanied by operations in the user query language that are extremely powerful, because they can be applied to entire tables instead of one record at a time. A weakness of many relational systems is that they often consume a great deal of computer resources when files become large.

In a hierarchical DBMS, data are stored in tree structures consisting of nodes of data connected by branches. The top node of the hierarchy is called the root. Every note except the root has one node (called the parent) above it on the tree, but a node may have several nodes below it. Nodes at the end of the hierarchy that do not have any nodes below them are called leaves. Hierarchical structures reflect relationships where an element in the structure has many attributes associated with it. A fundamental property of the hierarchical view of data is that any particular data element takes on its full meaning only when seen in the context of nodes higher in the tree. Since many real-world structures have a natural hierarchy, tree structures are very useful. One of the main advantages of these structures is that they can be very efficient with respect to computer storage space and access time.

Networks are data structures where nodes can have more than one parent. Any node may be linked to any other node. This extension to the basic tree structure is important in situations where data items may belong naturally to more than one owner. For example, consider a faculty member who has a joint appointment in two departments, or a project that is funded from several sources. A disadvantage of the network approach is undue complexity for many situations. Often this underlying complexity is reflected by a query language that is difficult to understand and use.

Mathematical studies of these different models show that it is possible to map values from any of the models to any of the other models. The main differences among the models are the ways in which they relate different attributes to entities and the number of physical storage elements they contain. Performance issues are also important both in machine utilization and human factors. Several empirical studies have been reported[2] that compare peoples' interactions with these data models and with various query languages along metrics such as ease of use, learning time, productivity and retention.

A major purpose of any information system is to provide an accurate and efficient model of the significant resources of an organization. The criterion of efficiency is the driving force behind most of the work on computerized information systems. Human efficiency is even more important than computer efficiency because the costs of hardware continue to decline while salaries continue to escalate. The trend in DBMS design is toward simplicity of logical representations of real world situations and ease of use of query languages. A significant amount of research is directed also to better system performance because a well-designed file organization can often provide access times that are more than ten times faster than straightforward implementations.

FEATURES TO COMPARE

When comparing different DBMS, managers should obtain information on important features useful in deciding which system best fits the needs of their organization. Several dimensions that are important in such evaluations are presented below.

Conceptual model for representing data — The previous section of this paper described the three basic logical models commonly used in current DBMS (relational, hierarchical, and network). It is important that the model chosen for a particular environment reflects the essential real-world features of the most important applications to be implemented.

Lockout — the ability of the system to protect a portion of the

database on which one user is working from simultaneous access by another user. Lockout can be achieved at different levels, with the more attractive systems offering lockout at more detailed levels. Lockout can be invoked during different phases of work, with better systems limiting lockout to the least time consuming phase when the database is being directly addressed by the user.

Journaling — recording transactions in a database for purposes of audit and reconstruction from a system failure. Well-designed journaling functions keep records of items such as:

- changes to the database
- who made the changes
- when change are made
- unsuccessful attempts to access protected fields or functions

A good database system can reconstruct a series of update transactions from the time a user began entering data until the time of a system failure.

High level language interface — this interface allows the database system to receive information from and deliver information to other applications on the computer system that are separate from the DBMS. Attractive DBMS will have interfaces for several high level languages like FORTRAN, BASIC, COBOL, etc. For example, a general ledger accounting package should be able to access salary data stored in a personnel database.

Views of data — the ability to view data in the database selectively, based on both the needs and the security level of the user. Powerful database systems provide a flexible viewing capability for inquiry, updating, and reporting of data.

Screen generator — this software allows the user to define how data are presented on the terminal screen (or printed out on a printing terminal), what prompts are given to the user, what help messages are available, whether features are available to expand various codes, etc.

Query language — this software allows the user to specify the criteria on which data are to be selected, sorted, or otherwise processed. This language is often the primary user interface for the nontechnical user. There are several new approaches to query languages such as IBM's query by Example (QBE) that are very easy to learn and use.

Updating and deleting — the mechanisms available to selected individuals for modifying data stored in the system. Two of the primary reasons for computerizing important files are that data elements change frequently, and that many people need access to up-to-date information. These important maintenance tasks should be supported by easy-to-use software.

Security and backup features — the protection mechanisms available to safeguard the database from loss due to careless or malevolent actions, environmental problems, and disasters like fire. Individuals should be able to gain access to and modify data when they have the proper authority. Since one of the basic concepts of DBMS is to make more information available centrally, it is crucial that users have only selective access to different parts of the database.

Computer environment — the hardware, software, and operating systems required to implement the DBMS. There are dozens of different DBMS available, and some operate only in special computer environments (on machine X with operating system Y). A great DBMS that runs only on equipment not at your installation is not very useful.

Performance — the ability of the software/hardware combination to do an important application within reasonable response times. DBMS often have the characteristic of being able to respond to certain types of requests quickly while taking a very long time to respond to others. This property is illustrated well by considering the indexing structure of the common telephone book. It is easy to find the phone number for John Smith, but it is very difficult to find the person whose number is 555-1234. Some systems work well as long as the size of the database remains below a critical value, but slow down dramatically if the data grow beyond this limit. Other systems work well as long as only a few people are using the system. Vendors should be asked to demonstrate systems running applications similar to the ones planned for your environment, or to perform benchmarking tests on your data under loading conditions you are likely to encounter.

Price — DBMS are expensive investments where prices are often based on the size of the computer system on which they will run. Major mainframe manufacturers usually lease their software on a monthly basis, and implement vendors usually charge a one-time license fee and yearly maintenance fees. Typical prices of DBMS are often fifty-thousand dollars or more for larger computers, twenty-five thousand dollars for powerful minicomputers, and five-hundred dollars for microcomputers.

Vendor support — training, installation, response to questions, application design, consulting, and ability to correct malfunctions. DBMS are complicated software systems that require professional support both from within the organization and from the supplier. Vendors often price such support separately from the software.

A recent survey[3] described fifty-four database management systems, offered by fifty different companies, that run on mainframes and minicomputers. The largest vendors ranked by sales were IBM (IBM,DL/1), Cincom (Total), Cullinane (IDMS), Intel (System 2000), Software AG (Adabas), and Infodata (Inquire). These vendors had

eighty percent of the market consisting of over eleven thousand installed systems. The market appears to be growing about thirty percent per year. The microcomputer DBMS market is in the early stages of explosive growth that is very difficult to track at this time. During the next few years a small number of DBMS will probably emerge as the leaders in this volatile market. A good fact to remember when looking at micro-based DBMS is that the first few companies to offer microcomputers are not even in business now. The same shake-out occurred in the hand-held calculator market. Caveat emptor!

A STRATEGY FOR MICRO-BASED DBMS

Since many of the advantages of a DBMS relate to the concept of an organization-wide centralized data base, what are the values of microcomputer-based data management systems? For the very small organization most of the justifications for the centralized data base of important information are still valid, but the system can be a microcomputer instead of a larger system. A more interesting case is the smaller department of a larger organization. Here the discussion splits reasonably well into two subproblems — when the larger organization does, and does not, have a central DBMS.

If an organization has a centralized DBMS, there may be no need for a departmental system implemented on a micro. However, it is sometimes useful to search a very large file for only those items of interest to a department and to make a local, temporary copy of these data for analysis purposes. This mode of operation implies a level of cooperation (communications, file formats, query languages, etc.) between the central system and local micros that is currently possible, but difficult to achieve. The reasons that local analysis and use may be more attractive than centralized processing are as many and varied as the general reasons that people find micros to be so valuable (economics, access, ease of use, response time, etc.). For example, a departmental administrator may want a localized database of all personnel associated with the department for budget projection, proposals, address lists, etc. A coordinated approach to the design of such a departmental system can avoid duplicate data entry and file maintenance. Obviously a major future required of a micro DBMS in this environment is the ability to work well with the central system.

If there is no central DBMS available, a department or project may want to implement its own for the same reasons any small organization would like a computer-based information system. In this case there are no real problems of coordination until other departments also implement their own systems. Without an organization-wide strategy, a "Tower of Babel" is likely to develop. Even with coordination it may be very difficult to achieve many of the benefits of a centralized

DBMS. Recognizing these potential problems, a department or project can still implement a useful micro-based system that may have a productive life of years before the organization implements a more coordinated approach.

One of the very important benefits to any manager of dealing with a micro-based DBMS is the learning that will take place. The complexity of large information systems can often obscure their overall design and make them seem unapproachable by non-technical users. However, a well-designed, well-documented micro DBMS can teach an individual how to organize files, manage data, and use query languages. These concepts can be generalized to more complex systems. Often this knowledge is sufficient to enable an individual to overcome his or her fears about complicated systems and become much more innovative in using them. In addition, individuals can often achieve substantial increases in personal productivity by organizing their personal working information on a microcomputer (project data, mail and telephone lists, budget information, correspondence, etc.).

CONCLUSION

People concerned with the use of information technology throughout an organization should exercise leadership in the database management area. An organization should exercise leadership in the database management area. An organization's approach to the opportunities presented by technological advances in this field should be planned aand then communicated widely. Many different strategies are workable, and there is no one "correct" solution for all organizations. The important point is that every organization should have a general framework into which departments and individuals can construct their own customized systems. Without such a plan it is very difficult for a decentralized department to know how to move without causing more problems than it is solving. With an overall plan the problems concerning which database to use, on which type of machine, for which application, and by whom, are difficult, but they are solvable.

Footnotes

[1] Date, C. J., *An Introduction to Database Systems*, 2nd Edition, Addison-Wesley, Reading, Mass., 1977.

[2] Reisner, P., "Human Factors Studies of Database Query Languages: A Survey and Assessment," *ACM Computing Surveys*, Vol. 13, No. 1, March, 1981.

[3] Krass, P., Weiner, H., "The DBMS Market is Booming," *Datamation*, September, 1981.

8

A PLAN FOR ACTION

John F. McManus

John F. McManus is director of Academic Computing at Pepperdine University. He is responsible for all instructional computing support at the Seaver College liberal arts undergraduate school, as well as the professional Schools of Law, Business and Management, and Education and Psychology. Dr. McManus is author of several articles, including co-authorship of a chapter in Campus Computing Strategies.

INTRODUCTION

Much has been said and published in the past several years about information processing literacy in higher education. In fact, the term, more commonly called "computer literacy" has been used so much, often without operational definition, that this concept at times fails to have meaning. It appears that computer literacy has vague, general support at all levels of education, but that implementation of this concept has been hampered by many factors such as cost, training, resources, or even knowing what to do.

Lest this paper contribute to the confusion already abundant, a rationale for computer literacy will be put forth. Based on this rationale, several alternative, but operational, sections will deal with current efforts at the higher education level, potential applications, issues surrounding the implementation of a computer literacy plan, and a scheme for implementing computer literacy.

RATIONALE

Why computer literacy, one might ask? Why, after living in a computer world since the 1950s that belonged to a select few, is it

critical that *all* individuals, all educated individuals in the 1980s, be computer literate? The reasons are many: availability, cost, power, practicality — but none perhaps so critical as the development of the silicon chip that has made computer power available to large segments of all industrialized, and to some extent agricultural, societies. The silicon chip that contains up to thousands of identifiable electronic locations has led to the development of the microcomputer. The silicon chip, together with the electronic products that it will spawn, is considered by some to be the most significant technological development since the printing press (of Servan-Schreiber and Molnar[1,2]).

It might be argued by some that nuclear fission and fusion, jet propulsion, the internal combustion engine and medical technology should also be considered worthy successors to Gutenberg's device. Perhaps, but such a discussion is not presented here. What is put forth is a firm belief that large scale integration of electronic circuits on chips now makes it possible for individuals and groups to generate and access more information than anyone could ever have imagined as few as ten years ago. Information provides knowledge; knowledge provides power; and power for good or evil is now in the hands of the computer literate. In one sense, the computer, whether it be micro, mini, mainframe, or supercomputer, now must be considered a water shed resource. It is an information stratum upon which other technologies, e.g., nuclear, medical, and communications, are based. The computer and its resultant capabilities can store such vast amounts of existing information and can produce through processing of numbers, words and symbols, new information at such a high rate of speed, that Nobel Laureate Herbert Simon has offered a new definition of the word "knowing." No longer, he feels, does knowing mean what a person has stored in his or her brain. Rather, knowing now means the ability to access information when required. The major tool for accessing information is the computer.

Jack McCredie, president of EDUCOM, and one of the featured speakers at this institute, puts forth an interesting argument for computer literacy — the pervasiveness of computers. Every aspect of our lives, personal, professional, and social, is touched by the computer. Some estimates indicate that approximately seventy-five percent of all jobs will have some relationship to computing by 1985.

DEFINITION OF INFORMATION PROCESSING LITERACY

It is not the intent of this presentation to put forth a categorical definition of computer literacy, or perhaps more appropriately of information processing literacy. Rather, I will discuss several possible definitions for consideration and will then make a strong recom-

mendation that each college and university strive to develop its own operational definition of this new literacy. In this process, I will offer Pepperdine University's preliminary definition with an accompanying comment on the purpose of that definition.

In 1981, the Academic Computing Advisory Committee (ACAC) of Pepperdine University requested that computer literacy be a requirement for graduation from Seaver College and the Professional Schools of Business, Law, and Education and Psychology by 1984. Computer literacy has been defined in the following manner:

1. The ability to identify the basic components of a computer;
2. The ability to write a program to solve a problem; and
3. The ability to use commercial software as an aid to information processing.

More recently, that definition has been expanded to include ethical considerations, social implications, and legal ramifications.

This commitment was approved by the Systems and Planning Committee, a group of operating vice-presidents who are responsible for all system-related budgets and activities.

In an attempt to augment the ACAC recommendation and to develop a plan for attaining computer literacy, Howard A. White, president of Pepperdine University, formed a Strategic Planning Task Force on Information Processing Literacy, made up of key university administrators. In March, 1982, he issued the following statement.

> . . . It is evident that the wave of the future demands that all students graduating from Pepperdine University become literate in the usage of information technology. Students should understand computing, word processing, communication devices and the integration of these to the extent that they can use this technology to solve problems, thus enabling them to compete in and contribute to the world in which we live.
>
> I am therefore appointing a small Strategic Planning Task Force to provide the administration with recommendations as to how best to accomplish this institutional goal by 1984 . . .[3]

The charge to this task force included seven specific tasks:

1. Define the necessary steps to be taken to accomplish the goal set forth;
2. Estimate the costs which would be directly related;
3. Identify potential funding sources for such a program;
4. Designate and prioritize training/education projects which would be required;

5. Identify curriculum issues which would need to be studied and recommend appropriate academic groups to address them;
6. Include all issues of significance identified through the work of the Task Force which need consideration; and
7. Prepare a strategic plan incorporating the previously mentioned items.[4]

Pepperdine is not the first school to commit to information processing literacy for all of its graduates, nor does it consider its definition unique or definitive. By design, there is much flexibility in the definition to permit each of the four schools within the University to determine its own needs and methods while conforming to the overall commitment to the University. Some efforts are currently in place. For example, the Graduate School of Education and Psychology requires a course in computer applications in management for all doctoral students in the Institutional Management program. The School of Business and Management requires experience in business simulation in certain MBA programs. The School of Law makes extensive use of LEXIS, a legal information retrieval system. Seaver College offers courses in computer science and programming and it is estimated that over sixty percent of the undergraduate population will take at least one computer course without the formal University requirement.

Do the existing activities at Pepperdine constitute literacy, using even the broad definition of computer literacy as recommended by the Academic Computing Advisory Committee? In some cases, the answer is no; e.g., LEXIS searches and business games. With the more formal courses, such as *Introduction to Computer Science*, the answer is closer to yes — for now. However, it is expected that the various schools will sharpen their definitions to include some issues as ethical, legal and moral implications, societal impact, long-range applications, communications, and the use of the computer as a personal tool.

IMPLEMENTATION — ONE SCHOOL'S APPROACH

How will computer literacy be defined? "How defined" has two meanings here: first, by what means; and second, by what activities and skills will computer literacy be operationalized? The first "how" is the easier question to answer — through top administrative directive. The schools will be asked to define their own computer literacy activities. This process includes all appropriate input, review, and approval procedures that are common to most schools.

The second "how," the operational definition, is much more difficult to determine. In fact, it would be presumptuous now even to intimate what should be implemented. However, at the risk of

intimation, let me put forth several components and procedures that could be considered.

Computer literacy aspects could include the following: word processing, statistical packages, modeling packages, information storage and retrieval programs, network database access, programming languages, system design, computer-assisted instruction, electronic mail, course-specific packages, computer graphics, computer-assisted design and manufacturing (CAD-CAM), computer-generated art and music, language analysis, concordances, key work in context (KWIC) searches, and machine repair. To this sample list must be added such components as the ethics of computing, the positive and negative legal impacts of computing, the effect on leisure time, and the impact of human social interaction. This list is sparse, more illustrative than exhaustive. However, it appears that many of the components will receive some attention by Pepperdine and by the schools that you represent.

The procedure for implementation can take one of two generic paths — either teach the components separately, or integrate them into existing and new course offerings. Traditionally, colleges and universities teach single subject matter courses such as physics, discrete mathematics, art, history and ethics. An argument which may be put forth is that these disciplines have such extensive content that the inclusion of other course and disciplines is precluded. For example, chemistry is often taught without formal concern of germ warfare; physics without discussion of nuclear holocaust; and computer systems programming without major concern over illegal electronic funds transfer. It may be the feeling of some instructors, we hope not at Pepperdine, that the implications of their disciplines are dealt with in other courses, and that the combined learning of multiple disciplines lead to a well-educated person.

I find a portion of this logic untenable with regard to some aspects of computer literacy. Almost without exception, instructors expect a minimum level of competence in reading, writing, and mathematics — the traditional three Rs. Callen and Holen[5] posit the argument that the three Rs should be augmented with a C, computing. While computing is certainly not discrete from the previous three, it can add a powerful dimension to the expected skills base of all students. Is it now unreasonable to expect students to possess at least a minimum competency in computer literacy? Pushing a bit further, is it not most reasonable that students understand the power of the computer, the power for good or evil, and consider this power in their pursuit of knowledge?

James Koerner, vice-president of the Sloan Foundation, feels that

the computer is becoming an essential tool to the liberal education. In a monograph, titled, *The New Liberal Arts,* he states,

> The computer is beginning to do for the mind of man what the engine did for the muscle of man . . . The computer (is) one of the most powerful tools that has ever been brought into being for the service of the individual who seeks to understand his world . . . That students be acquainted with the computer in some reasonably respectable fashion . . . is surely no more radical a thought than the proposition that they should be able to read and write.[6]

In the same work, Stephen White, director of Special Projects at Sloan, puts forth a rationale for the inclusion of computer literacy in the liberal arts when he says,

> What the computer has done . . . is provide scope for analytic skills that has never before existed, and in so doing it has altered the world in which the student will live as well as the manner in which he will think about the world. It is these basic facts that constitute the link between the computer and a liberal education.[7]

CURRENT EFFORTS

There are several projects underway in colleges and universities in America that demonstrate the dramatic efforts being proposed to attain computer literacy. The following schools represent both ambitious and outstanding examples of such efforts:

- Rensselaer Polytechnic Institute
- Carnegie-Mellon University
- Rochester Institute of Technology
- Pepperdine University

RENSSELAER POLYTECHNIC UNIVERSITY (RPI)

RPI has instituted a Darrin Scholars Program, conceptualized by Vice-President and Provost Harrison Shell. In fall, 1981, twenty-one entering freshmen were awarded a twenty-five hundred dollar scholarship and were presented with a fully configured ATARI 800 microcomputer. These students were encouraged to experiment with the micros, use them to assist in course homework, and meet once a week to discuss microcomputer concepts.

As an important part of the evaluation of this project, two psychologists, Linda Caporeal and Richard Park, together with researchers from Atari, are examining such issues as social interaction, problem solving, and personal and social decisions. Two control

groups at RPI are being used to compare effects. The first group is a heterogeneous group of freshmen who brought their own micros to RPI. The second group is similar to the Darrin scholars in aptitude, but they do not own micros. All students are requested to keep logs of their behaviors for one week in the fall and one in the spring.

Researchers will evaluate quantitative skills, e.g., programming, as well as qualitative behavior, e.g., social interactions. The global purpose of the study is to assess the value of the micro in an academic environment, to prepare for the time when personal computers will be the norm.

CARNEGIE-MELLON UNIVERSITY (CMU)

CMU is in the process of implementing a major commitment to computer literacy. In a presentation to the Special Interest Group for University Computer Centers and Services (SIGUCCS) in March 1982, Doug Van Houweling, vice provost for Computing and Planning, put forth details of the renowned "Carnegie-Mellon Plan." As presently planned, CMU will require that beginning with the freshman class of 1985, each student will be required to possess his or her own micro. The phase-in program will continue through 1989 or 1990.

While plans for assisting students in the financing of these micros have not been finalized, it is hoped that technological advances will help dissipate the problem by a dramatic decrease in the cost-to-power ratio.

It is estimated that within four years micros will possess ten times the computing power at one-fourth the current cost. Rough estimates would thus indicate that a half-megabyte machine will cost about five hundred dollars. This price, amortized over four years, should add minimal burden to the existing educational cost.

It should be noted the CMU intends to install very powerful micros, capable of high resolution graphics and sophisticated processing. CMU plans to permit students, faculty and staff to connect to a planned "backbone" network, allowing users to communicate with each other and to use the capabilities of larger processors on the network.

ROCHESTER INSTITUTE OF TECHNOLOGY (RIT)

RIT has committed four million dollars to faculty and student literacy. Initial plans called for the training of two hundred faculty members during a series of two week sessions in summer, 1982. In 1983, this program was expanded to include faculty from other institutions. The faculty literacy program is in keeping with Objective III of the objectives for computer literacy at RIT:

> Within two years a substantial majority of full-time faculty in each program will possess a level of basic computer literacy at least equivalent to that specified for students.[8]

Two additional components of the literacy plan have been approved by the RIT Policy Council. These are the development of a computer literacy course open to all students and a video tape course titled *Introduction to Microcomputing* to be presented on cable television. Explicit goal statements from RIT indicate that a sufficient number of faculty will be trained by 1985 to meet literacy requirements of students, and that by 1987, computer applications will be fully integrated, as appropriate, into every discipline at RIT. In addition, there is a major commitment to word processing, test generation, CAI and computer graphics.

It is interesting and encouraging to note that the definition of computer literacy at RIT will remain fluid. While basic literacy is defined as the ability to program at an appropriate level, to describe the basic components of a computer system, and to possess knowledge of software application to meet various career goals, the remainder of the RIT planning document allows flexibility in objectives, based on the technological state of the art and specific course requirements.

PEPPERDINE UNIVERSITY

Steps have already been taken to implement computer literacy at Pepperdine. Several one-day sessions have been conducted at Seaver College to introduce faculty to the applications of computer technology. In the first half of the sessions, experienced faculty present demonstrations of work underway. The use of faculty in this role can reduce the potential anxiety generated by more technical presentations. The second half of the session offers faculty the opportunity to try out equipment in the Academic Computing Laboratory with no students present. These one-day overview sessions are followed by small group tutorial sessions with Academic Computing staff, usually students, who instruct faculty on hardware and software applications.

A new freshman seminar was offered in fall 1982 in the Social Sciences Division. There are strong indications that this course, "Coping with Computers," will be extremely popular.

There is also much activity in the professional schools. The Graduate School of Education and Psychology has revised its doctoral course requirements to make the computer experience more "hands-on" and will offer a new Master of Science degree in Educational Computing. The School of Business and Management has recently revised its MBA curriculum, and up to sixty percent of the courses are

designed to implement computer technology. In the School of Law, the majority of work centers around word processing and on-line retrieval.

ISSUES SURROUNDING COMPUTER LITERACY

The preceding discussion has addressed many issues surrounding computer literacy. While many definitions and examples have been put forth, several implicit assumptions have been made concerning the entry skills level of persons approaching the computer literacy process. Most fundamental of these is the assumption that these persons are functionally literate in reading, computation, and writing. This assumption is based on the obvious need of an individual to handle the input, output, and processing requirements to the computer.

A NATIONAL ISSUE — LITERACY

An article in the May 17, 1982 edition of the *U.S. News & World Report* titled "Ahead: A Nation of Illiterates?" painted a bleak picture of the nation's functional literacy, i.e., the ability to read and write at a level sufficient to obtain and maintain a job and to survive in the society. The article states that twenty-three million persons in this country are functionally illiterate, and that an additional thirty million Americans are only marginally capable of productive work. The figures for minorities are especially disturbing. For example, fifty-six percent of Hispanics and forty-four percent of blacks are considered functionally illiterate.[9]

Many sociologists, educators, and perhaps technicians have felt that the advent of personal computers could reduce dramatically the achievement gap between the educationally disadvantaged and the remainder of the American society. However, if functional literacy is a requirement for computer literacy, will this gap be narrowed, or widened? There are yet no conclusive answers, but if the illiteracy rate of a significant portion of our society continues to grow, one conclusion is a society-threatening difference between those who have access to information and those who do not.

The implications of these statistics can be overwhelming, open to multiple conclusions. From a negative perspective, the outlook is devastating for many persons. One conclusion is that the proliferation of computing power in the general populace, or at least of a subset of that populace, creates a gulf between the "know" and the "know-nots" will grow to an immeasurable width. Information control, and subsequent political and economic control, will evolve to the computer literate. It is possible that within this group of computer

literates, a caste system will develop, leaving true power in the hands of a few. Who will these few be?

The most foreboding answer to the question is "Technocrats." In a presentation to the Pepperdine University Faculty in 1981, Stephen Tonsor of the University of Michigan painted a disturbing picture of a world ruled by technocrats — individuals who have access to power by virtue of their working knowledge of technological advances. The concern expressed was the fact that we may be living in a world controlled by persons whose values are based on technology itself, rather than guided by philosophers and humanists who would promulgate the personal and group values of a society or state. The major fear expressed by Tonsor was the fact that philosophy, values and ethics will be the result of technology rather than the guiding force in its development and use. He warns:

> Technology divorced from a rational and human context is the great danger to our era and to our society. Ultimately it will fail because it does not fulfill the human life but before that absolute failure it can and has done terrible damage.[10]

With the exception of a handful of high-technology schools such as Carnegie-Mellon University, Rensselaer Polytechnic Institute, California Institute of Technology and the Massachusetts Institute of Technology, and some universities who have built computing into their curriculum, such as the University of California, Irvine, every school that is addressing the issue of information processing literacy must face the following issues if it hopes to attain a marketable education product: institutional commitment, faculty and staff training, curriculum evaluation, space considerations, cost of hardware and software, and network configurations.

An attempt will now be made to examine some details surrounding each of these issues, and then suggestions will be put forth to meet the challenges attending each issue.

Institutional Commitment. It can be argued that any school that does not have top level administration support for information processing literacy will fail in its effort. This proposition is espoused by Pepperdine University, and is commonly, but not universally, held by prime movers in the field. In its *Five-Year Plan* the Computer Services lists administrative support as one of its six critical success factors.

Faculty and Staff Training. As previously mentioned, the Rochester Institute of Technology is attempting to raise the level of the computing competence of their faculty at least to the level of their students. In such a school this can be an awesome task. But what of a less technical school? Is the task less imposing? One could hardly

imagine that this is the case. In fact, I would dare to state that the most serious problem in computer literacy that confronts America's colleges and universities is the training of faculty and staff (I conveniently ignore the problem of money in the present instance).

Who will train? Who will prepare instructional materials? Most likely, the training will be done by the more proficient faculty and staff. Computer center personnel may also be helpful. I would, however, respectfully urge each of you to make use of the greatest source of untapped talent on your campus — your students. Have you ever been taught by your students, at least informally? Try it. It can be an enlightening experience.

Curriculum Evaluation. There are no easy answers here. All changes to curriculum must be worked out course by course, division by division, department by department, school by school. Modifications to curriculum must take into account the mission of the school, its values, its strengths and its direction. In general, two approaches may be taken, horizontal or vertical integration. Horizontal integration involves the weaving of computer literacy into courses, often in an instructional module fashion. Vertical integration implies much more direct change in the curriculum and considers such issues as addition of new courses and deletion of old. It is not unreasonable to consider a combined approach that does not threaten the fundamental character of the institution.

Space Considerations. I mention this concept because it is very critical to Pepperdine University and perhaps to some of the institutions represented here. Whether there are declining enrollments, space may not be a critical factor. However, every institution must consider the quality of space and address such issues as environment and security.

Cost. There is no way to avoid the issue of cost. Computers cost money. Granted, the price per computing unit is dropping rapidly. Within several years, the cost of computers may not be significant. However, you do not have several years. You must act now. Some possible ways of supporting the acquisition of hardware and software include the following:

- — establishing a relationship with a computer vendor, whereby your school becomes a test site or showcase;
- — seeking external funding from private and public sources;
- — developing creative financing strategies [a warning: do not get so creative as to go bankrupt]; and
- — primary computer-related acquisitions.

Whatever combination of approach you tale will be painful. It will not be easy. But what is your alternative?

Network Configurations. It is very important that there be a master plan for integrating your efforts to maximize use of all of your

capabilities. Design of a network can be a fine forcing function to that end. Whether the network be phone, switch, cable, or twisted pair wires, make sure that resources can be shared and that users can communicate. The use of central mass storage, for example, can reduce the need for local storage and thus reduce the cost of microcomputers. The ability to download files for remote processing can reduce the burden on the central processor, possibly reducing costs and increasing flexibility. Design your computer plan around your network. This approach is much easier than attempting to permit incompatible equipment to communicate.

A PLAN FOR ACTION

To present a plan for implementation of computer literacy that is right for each of the institutions that you represent is neither appropriate nor possible in this setting. Rather, let me put forth for your consideration several schema, or outlines, and ask that you determine what your school should do.

FIGURE 1: Information Processing Literacy Continuum (Adapted from Richard Van Horn)

WHERE ARE WE?

HIGH TECH — BASIC CORE — LITERACY — ELECTIVE

1. _____

WHERE DO WE WANT TO BE BY 19___?

HIGH TECH — BASIC CORE — LITERACY — ELECTIVE

2. _____

Difference between #2 and #1 is the scope of task before you.

Information Processing Literacy Plan Outline

1. Who determines direction? _____
2. Who carries out planning? _____
3. How is plan approved? _____
4. Who implements plan? _____
5. How do you acquire: _____
   - A. Hardware _____
   - B. Software _____
   - C. Space _____
   - D. Staff training _____

1. *Define Your Mission.* Where is your institution headed? What are its strengths and weaknesses? How will it attain its goals?

Much of this information can be derived from two key documents — your mission statement and your strategic plan. If either of these documents does not exist, or if such documents do not reflect the role of your institution, ask yourself why.

2. *Determine The Desired Level of Computer Literacy Involvement.* Implementing a plan of computer literacy is a major commitment. Before making this commitment, a school should determine its goals or strategies. From this determination emerge many of the skeletal details of implementation requirements. Figure 1 presents a strategy chart that may prove helpful.
3. *Outline Your Implementation Plan.* Figure 2 presents an outline for structuring your computer literacy implementation. The outline puts forth several questions that may appear to be deceptively straight forward. I strongly urge that your institution attempt to answer these questions.
4. *Finally . . . Do It!* Implementation of a computer literacy plan is an arduous process. It is difficult, expensive, fraught with problems, often met with resistance, time consuming, and sometimes obsessive, but it is worth it. Figure 3 presents some of the issues that must be answered.

FIGURE 2: Information Processing Literacy Implementation Issues

1. Strategic plan
   A. Where are you heading?
   B. How will you get there?
   C. Who is involved?
2. Target audiences
   A. Students
   B. Faculty
   C. Administration
   D. Staff
3. Selection of Equipment
4. Funding
5. Space
6. Software Library Maintenance
7. Hardware Maintenance
8. Communications/networks
9. Management of resources
10. Training
11. Others:
    A. _____
    B. _____
    C. _____

FIGURE 3:

1. #/Students _____
2. #/Faculty _____
3. #/Terminals to Main Frame _____
4. #/Micros (stand alone only) _____
5. #/Micros to Main Frame _____
6. Student/Terminal Ratio (Line 1 ² Line 3) _____ :1____
7. Student/Micros Ratio (Line 1 ² Line 4) _____ :1____
8. Student/Micro-Terminal Ratio (Line 1 ² Line 5) _____ :1____
9. Faculty/Terminal Ratio (Line 2 ² Line 3) _____ :1____
10. Faculty/Micro Ratio (Line 2 ² Line 4) _____ :1____
11. Faculty/Micro-Terminal Ratio (Line 2 ² Line 5) _____ :1____

What is **desired** ratio for #6-#11 above?

	Actual	**Desired**
6.	_____ :1____	_____ :1____
7.	_____ :1____	_____ :1____
8.	_____ :1____	_____ :1____
9.	_____ :1____	_____ :1____
10.	_____ :1____	_____ :1____
11.	_____ :1____	_____ :1____

CONCLUSION

A long journey confronts you all. Do not travel alone. Share your individual experiences with others in this group as you return to your own institution. Read about and write about efforts to reach the lofty goals we are setting for ourselves this week. Give each other counsel and solace. Persevere.

Footnotes

[1] Jean-Jacques Servan-Schreiber, *The World Challenge*, New York, Simon and Schuster, 1980.

[2] Andrew Malnar, "The Next Great Crisis in American Education: Computer Literacy," *EDUCOM Bulletin*, Spring 1974, pp. 2-6.

[3] Howard A. White, "Charge to the Strategic Task Force for Information Technology Literacy," Mimeographed, Malibu, California, Pepperdine University, March 1982.

[4] *Ibid.*

[5] Callen and H. Holen, "3 R's and C (Computer Illiteracy)" *College News and Views,* Spring 1982, pp. 19-21.

[6] James A. Koerner (Ed.), *The New Liberal Àrts: An Exchange of Views,* New York, Alfred P. Sloan Foundation, 1981.

[7] *op. cit.,* Stephen A. White, p. 5.

[8] Wiley McKinzie, "Critical First Steps: Objectives for Academic Computing at RIT," Mimeographed, Rochester, February 2, 1982, p. 39.

[9] Stanley Wellborn, "Ahead: A Nation of Illiterates?", *U.S. News & World Report,* Vol. 92 No. 19, May 17, 1982, pp. 53-57.

[10] Stephen J. Tonsor, "Why Democratic Technocrats Need the Liberal Arts" in *Freedom, Order and the University,* James R. Wilburn (Ed.), Malibu, Pepperdine University Press, 1982, p. 28.

9

DECISION SUPPORT SYSTEMS

Larry N. Craft

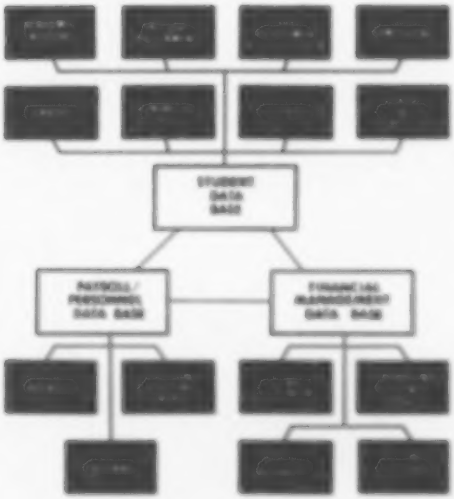
Larry N. Craft is director of Administrative Services, System and Computer Technology Corporation. Dr. Craft has served as a consultant to colleges and universities in the development of computer-based student information management systems and has authored numerous papers and research reports.

Compared with the thousands of articles and works written about automation and systems over approximately the past twenty-five years, relatively little exists that is directly related to Decision Support Systems (DSS). What there is has mostly appeared in the last three years. Rather than review that literature, this article will provide a composite case study approach, using elements encountered in discussions with chief executive officers (CEOs) in higher education since 1979, resulting in a DSS prototype. By using this approach, and studying issues that will be close to the hearts of college/university presidents and trustees through the 1980s, the esoterica or computerese can be minimized without loss of the practical implications afforded through DSS employment.

Decision support systems rest at the top of a series of system building blocks. Of the six or eight total blocks, we will focus on the topmost three: *Applications Systems* (illustration 1) which support daily or recurring operational activities, *Management Information Systems* (illustration 2) which use a combination of applications to provide a manager with data for tactical planning and operation, and DSS, which potentially draw on the total mix of Administrative Systems (ideally in a database management structure) and manipulate data from these through one or a number of modeling software

ILLUSTRATION 1: Student Information System

ILLUSTRATION 2: System Integration



BEST COPY AVAILABLE

packages. (See illustration 3.) The successful DSS attempts to address five major dimensions:

1. *Environmental* — Economic, competition, socio-political, etc.
2. *Program* — Majors, curriculum, placement/industry considerations, etc.
3. *Behavioral* — "Soft" data, individual/interpersonal constraints and latitudes.
4. *Structural* — Reporting relationships, distribution of functions, policy, etc.
5. *Strategic* — Mission, geographic market limits, competitive emphasis, objectives, etc.

(Modified from Shirley, Peters, and El-Ansay, 1981.)

A DSS should be able to manipulate dozens of variables associated with the dimensions above, and literally hundreds of assumptions a CEO might wish to incorporate in "what if and/or when" modeling exercises.

If we examine today's real world, we find CEOs in higher education concerned about enrollment, recruiting *and* retention, and budget, operating and capital. Focus is intensifying in these areas for two basic reasons:

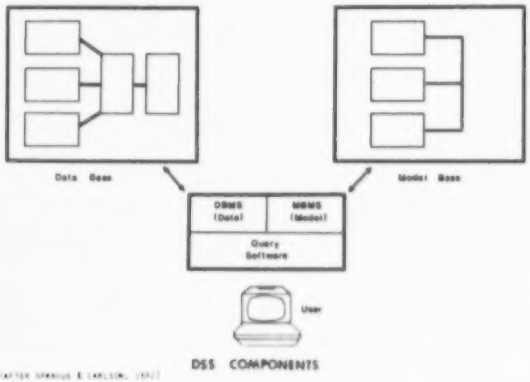
- A limited pool of target recruits (either numbers or quality-wise, or a combination), and
- Real and projected decreases in government spending in the higher education sector. As an example, financial aid to students from the federal government may decrease by as much as sixty percent between May 1982 and October 1985.

A tremendous amount of data (related to the anticipated situations) may exist in a given institution which, if properly assembled and manipulated, could aid the CEO in heading off a potentially disastrous situation for his or her institution. Employing existing data in a DSS-ready environment, and using a number of "knowns," the process might go something like this:

KNOWNS

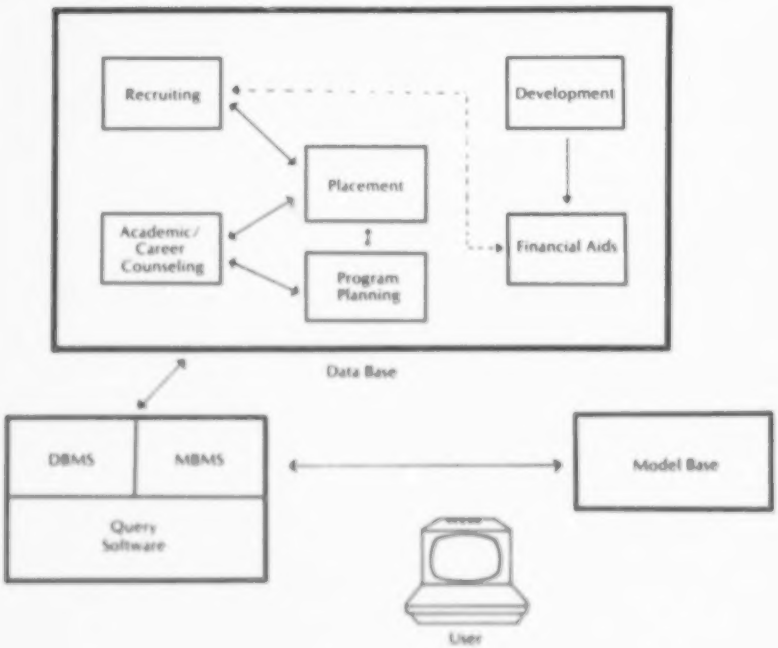
1. The most powerful recruiting tool is a consistently good placement record;
2. The development office must replace some portion of the lost financial aids budget;
3. Academic programs must become more cost-effective in their structure and delivery;
4. We must recruit for "successes" based on a successful student profile;
5. We must improve student retention programs; and

ILLUSTRATION 3: DDS Components



DSS COMPONENTS

ILLUSTRATION 4



6. The return on investment, whether in purchasing, recruiting, computing or endowment portfolio, must improve (unless budget escalation is permissable).

EXISTING DATA

1. Recruiting/enrollment-related;
2. Placement (at least in federal reporting areas);
3. Financial aid funds by category (and by expense lines);
4. Program enrollment (numbers of students/class/professor/etc.);
5. Retention successes/failures; and
6. Development-related funds currently available.

If we convert our hard and soft information to a system structured to support strategic and tactical decision needs we might evolve something like illustration 4.

DISCUSSION

- Placement records must be available in an automated mode—who/how many employed where.
- The development office(rs) must follow alumni to employers (as well as individually); unlike headhunters, colleges and universities charge no fee for placements and business recognizes this (and would contribute) and could do much to offset lost financial aid dollars.
- Program support (and new program development) more and more reflects recruiting and placement successes.
- Regarding retention, an active counseling program frequently embraces sophisticated guidance/counseling software packages (e.g., SIGI) for individualized use by students.
- As stated above, the most powerful recruiting tool is a good placement record; most institutions are unable to leverage this resource because the necessary information resources are not systematically linked and supported.

EXECUTIVE SUMMARY

- Management information systems have been minimally useful in planning or in the improvement of decision effectiveness; DSS are designed to overcome these shortcomings.
- Management Information Systems (MIS) typically operate from current data, within a fiscal or academic year/term; DSS are best employed when longitudinal data are available.
- MIS provide data details; DSS summarize information.
- Although presented here for interest of a senior/executive level, DSS are needed at all organizational levels.

- Since a DSS is not a stand-alone resource, it employs data and characteristics from other database environments. Acquiring a full-blown, optimum DSS can be expensive; with or without the formal software, we all do use with some level of success, a DSS concept with every decision we make. With a DSS we can test, validate, weigh alternatives, etc., in a matter of minutes or hours—something the average mind cannot do. In the face of the challenges the 1980s present, we need every advantage we can get with every decision we make. In that light, DSS may be just the ticket!

References

Bonczek, R.E., Holsapple, C.W., and Whinston, A.B. *Foundations of Decision Support Systems.* New York: Academic Press, 1981.

Feldman, M.S. and March, James G. "Information in Organizations as Signal and Symbol." *Administrative Science Quarterly,* Vol. 26, June 1981.

Hackman, J.D. and Libby, P.A. "Toward More Effective Strategic Planning: Annotated Readings about Planning, Human Information Processing, and Decision Support Systems" *Planning for Higher Education,* SCUP, Vol. 9, No. 4, Summer 1981.

Hopkins, D.S.P. and Massy, W.F. *Planning Models for Colleges and Universities,* Stanford: Stanford University Press, 1981.

Huber, G. "The Nature of Organizational Decision Making and the Design of Decision Support Systems." *MIS Quarterly,* June 1981.

Keen, P.G.W. and Scott Morton, M.S. *Decision Support Systems: An Organizational Perspective.* Reading, Mass.: Addision-Wesley, 1978.

Mims, R. Sue, "Decision Support Systems for Colleges and Universities." A paper presented at Texas Association of Institutional Researchers annual meeting. Office of Academic Planning and Analysis, U. Mich., March 1982.

Rockart, J.F. and Treacy, M.D. "The CEO Goes On-Line." *Harvard Business Review,* January-February 1982.

Shirley, R.C., Peters, M.H., and El-Ansary, A.I. *Strategy and Policy Formation.* New York: John Wiley, 1981.

Sprague, R.H. and Carlson, E.D. *Building Effective Decision Support Systems.* Englewood Cliffs, N.J.: Prentice-Hall, 1982.

Ungson, G.R., Braunstein, D.N., and Hall, D. "Managerial Information Processing: A Research Review," *Administrative Science Quarterly,* Vol. 26, March 1981.

Weiss, C.H. "Knowledge Creep and Decision Accretion." *Knowledge: Creation, Diffusion, Utilization,* Vol. 1, No. 3, March 1980.

10

SOCIAL, ETHICAL, AND LEGAL ISSUES OF COMPUTING

Kenneth H. York

Kenneth H. York is distinguished professor of law at Pepperdine University. He served as professor of law at UCLA from 1950 to 1979 where he was faculty editor of the UCLA Law Review. *He has authored numerous articles in law reviews and the* Journal of Legal Education.

The topic "Social, Ethical, and Legal Issues of Computing," has an almost cosmic breadth to it which we should approach cautiously. To reduce the subject to manageable sub-topics, I will begin with "Social Issues of Computing."

Certainly, the social consequences of the computer revolution will be enormous. More computers than people exist now. Computers are in pockets, on wrists, and perhaps some people are held upright by computerized devices ticking away, implanted someplace in their anatomies. The almost unimaginable number of instances of our future daily personal contacts with a computer terminal will drastically rearrange our societal structure.

What I may say in this presentation about law, ethics and computers will implicitly involve social consequences, but to visualize and describe broadly the computerized society of the future requires a breadth of imagination, of technical awareness, and a soaring intelligence to which I do not pretend.

For the moment, let us get back to a reduced agenda and, for me, the more comfortable subject of law and computers. Computers and the law touch, or, to use the jargon of the computer age, interface at many points.

Most entertaining to the general public are the publicized instances of the misuse of computers, sophisticated white-collar crime and semi-amusing pranks by precocious juveniles. We are all fascinated by the exploits of the chap who winkled out approximately thirteen million dollars from Security Pacific Bank through computer manipulations, ran the proceeds through Swiss banks and into a bag of diamonds from the Soviets. He was released after three years in confinement. All of this is material for the weekly tabloids, and parenthetically, for the professor to instruct upon the principles of *tracing*, of *Jessels' Bag*, *Knight Bruce's Chest* and such quiddities of the law. It is also deadly serious business, however. Computers are weapons. Computers do not commit crimes — people commit crimes. At the command of the wrong people, the computer is capable of incalculable harm. The situation is as dangerous, as the Marine Corps doctrine has it, as a second lieutenant with a fountain pen. If the experts are unable to come up with impenetrable internal defenses to the misuse of computers, the problem becomes one of the criminal law. The attention which is being paid to the problem by the legal profession is best confirmed by the bibliography on the subject in a 1982 issue of *The Record*, a publication of the association of the bar of the City of New York, listing 111 books and major articles. There have been more since.

Misuse of computer facilities also gives rise to civil litigation. Suppose some twelve-year-old prodigy gains access to your university's computer and wipes out all the academic records. Although there are ample means available to the civil law to deal generally with this variety of wrong, the problem is not quite so simple as someone cutting down his neighbors' trees; and I can assure you that decisions as to the measurement of damages — values of the tangibles, such as tapes; value of the information, cost of reconstruction of the data — or specific remedies such as mandatory injunctions, etc., will knit many a judicial brow.

A closely related form of computer misuse is of concern to all of us. It involves our privacy. We are quite aware that vast amounts of personal data may be accumulating somewhere. Our finances, our medical data, our sins, our foibles, and, to what we used to say, "heaven only knows," are being deposited in data banks where people we would prefer not to now have check-writing privileges. The law indeed protects our right of privacy; which right however, comes somewhat late on the legal scene.

Lawyers are not exactly sure of what it is we are protecting. Not long ago Californians voted a right of privacy into the State constitution, without any firm definition. But it sounds good. As the tort came to be delineated, it embraced such conduct as presenting individuals in a

false light; or using a person's name or likeness for purposes of advertising or trade; or the annoyance of Jacqueline Onassis by photographers. To us as individuals, the important form is simply the right to be let alone — not so much in a physical as in a dignitary sense. But to state this as a legal "right" carries with it the Hohfeldian correlative of a legal "duty," and who can say with absolute certainty what is the extent of our legal duty to stay out of somebody else's affairs, particularly when we have strong claims of privilege in our own interests? How wide a moat are people entitled to place around themselves? Everyone here representing a university administration is aware of the troublesome legal restrictions now imposed on the disclosure of students' and employees' records, as well as the countervailing assertions of the "right to know" by the press under the "Freedom of Information Act." This delicate balancing of interests is a major concern to those involved in computer record handling. And the law in the form of statutes and legal opinions will for a long time be involved in reducing these issues to a tractable form.

A sample case which reached the U.S. Supreme Court[1] illustrates the legal dilemma. The question was whether New York can record on a centralized computer file the names and addresses of all persons who have obtained doctor's prescriptions for drugs which have both a lawful and unlawful market. The federal district court said no; the Supreme Court said yes. Or let me pose for you a simple problem. A bitter battle for custody of a child exists. One spouse moves for discovery of the computerized health records of the other. How would you rule as judge? These are old problems (the example would be a fit for Solomon) in a way multiplied by a factor corresponding to the increase of computer data banks.

Another point at which the law touches the computer world has to do with the rights of control of computer technology. Billions of dollars are at stake here, and that attracts attention, even that of lawyers. Although we take a very dim view of monopolies, a legal exception has been devised to appropriately reward inventiveness. The federal government exclusively runs the patent and copyright systems, which, for a limited time, attempt to guarantee the inventor and creator a financial reward; in short, a temporary monopoly. Computer hardware inventions are protected by patents, and computer software can clearly be protected by copyright.[2] There are certain drawbacks to copyright protection, however, because the copyrighted matter may be open to public examination. What cannot be copied is the expression of the idea, not the idea itself (several hours' — or years' in the case of lawyers — thought may lead to a realization of what that means). The patent, it is said,[3] offers more protection to the inventor than the copyright which does not protect the techniques

and processes of development of the inventor's ultimate creation. There has, therefore, been much interest in whether computer software could be patented. According to Title 35, §101 of the U.S. Code, the object of a patent must meet certain subject matter qualifications — i.e., must be a process, a manufacture, a machine, or a composition of matter. Obviously, certain things are not patentable. Mathematical formulas or the principle of electricity are not patentable. Most important, as regards computers, is the fact that "mental processes or steps" per se are not patentable. Computer software has been considered as falling into this category because the process involved can be worked out mentally, and in many instances would also constitute mathematical formulas. As recently as 1978 the Supreme Court of the U.S.[4] considered the patentability of a computer software program to provide an alarm when a petroleum refining process went awry. The alarm limit was held to be merely a number calculated by the computer and therefore not patentable.

In 1981 the Supreme Court in *Desmond v. Diehr*[5] again addressed the problem. Diehr and another applied for a patent for molding synthetic rubber. The curing of the rubber requires a concurrence of temperature and time. This information was fed into a computer which was programmed according to a mathematical formula to cause the molds to open automatically at the correct time. The patent examiner said no patent; the U.S. Patent and Trademark Office Board of Appeal said no. But the Court of Customs and Patent Appeals said yes, as did the U.S. Supreme Court. Apparently this means a computer software program consisting mainly in a mathematical formula is indeed patentable as long as it is an integrated ongoing feature of a mechanical process. The full impact of this decision may not be known for some time, but it is assumed that new inventions utilizing computers will be encouraged.

The common law also affords a type of monopoly to trade secrets for which there is no statutory protection. Indeed such a monopoly exists as long as the secret can be kept, whereas patents or copyrights expire. A favorite example is the Coca-Cola formula which, if patented, would long since have been in the public domain.

Trade secrets are notoriously difficult to protect, however. Discovery destroys the protection and industrial spies abound. Employees have knowledge of trade secrets, or at least portions of them, and may take them with them in leaving employment. Contractual undertakings not to disclose trade secrets by those in the know are valid, but enforcement is difficult because of remedial problems; damages are hard to prove, let alone collect, and specific relief by way of injunctions is quite unsatisfactory. Besides, the litigation process virtually guarantees placing the secret in the public domain. A case

pending before the Wisconsin Supreme Court is instructive. M. Bryce & Associates, a Cincinnati consulting firm, put out a manual on data processing upon which a copyright notation was placed. The distribution was confidential and internal. Arthur Young & Company was accused of pirating the ideas embodied in the manual. The copyright, claimed Young, applied only to the expression, not to the ideas. A ten thousand dollar judgment was entered against Young nevertheless on the grounds this was a state trade secrets case, not a federal copyright case. The appeal is pending.[6]

Another legal rationale, standing apart from statutory procedures, has been developed which may be used to protect the developer of novel systems of computer software. It can be described as the "misappropriation" theory of unfair competition, and is traceable to one of the more famous cases of the law, International News Service (INS) v. Associated Press (AP)[7] back in 1918, arising out of the handling of news dispatches during the First World War. AP, at considerable expense, maintained correspondents on the western front dispatching daily reports which AP supplied its subscribers. It also posted the reports at its New York headquarters. INS, on the other hand, saved the costs of news gathering; it merely had an employee copy the AP reports and then forward dispatches to its subscribers. To a West Coast newspaper the time differential in receiving the news was hardly great enough to outweigh the less expensive INS version. Now news cannot be patented, copyrighted or kept secret. Nor can it be owned in the familiar sense of the word. But INS "had reaped where it had not sown," and the U.S. Supreme Court decided the news could be considered as quasi-property and its "misappropriation" could be stopped. Broadly put, the doctrine protects the people who bear the costs and time of doing research and development from the depredations of the lazy privateers cruising the commercial seas. There are limitations on the "misappropriation" doctrine: (1) it is not recognized in all states; (2) it may be held to be pre-empted where copyright or patent protection is available; and, (3) the protection is of short duration. What is protected in the INS case is the commercial value of news while it is fresh, not the news itself. Next week it is not news and anyone can do with it what he or she pleases. Therefore, the person developing software programs will receive protection from competition under this theory only for the period during which the program could normally be researched and developed independently — what is called "lead" time.

Let us turn now, rather abruptly and disjunctively, to the other main portion of the billing — ethical issues of computing. For guidance on this matter I did the logical thing and consulted a computer. Computers have been put to many uses within the legal profession,

particularly with regard to the search for precedent. One remarkable system called LEXIS uses a method which is essentially the matching of key words. If the key words of a legal problem are identifiable, a similar conjunction of words in a prior decision should involve a similar problem. A computer search locates instances of such conjunction, a portion of the text appears on the screen, and the operator, if convinced the search has been successful, may then get a complete case printout. With the aid of the library staff, we asked LEXIS for the citations from all reported federal and state opinions of instances where the words *computer* and *ethics* appeared within twenty words of one another. The answer was "none." Although this might seem surprising, the reason, I suspect, may be simple — a computer cannot be programmed to be ethical or equitable. It has no conscience and cannot be given one. No doubt this proposition has been advanced in different ways — such that computers have no emotions or no soul — but I would like to describe it in the terms of our system of jurisprudence and its history, in a very foreshortened and abbreviated fashion.

A main component in our system is the law embodied in statutes and in the common law inherited from England. To the judges of the common law courts of Britain, we owe an inestimable debt. They declared what the law was, and had the very risky temerity to assert that no one — including the King — was above it. To such judges, e.g., Lord Coke — a lion who was not disposed to lie tamely under the throne, we owe the independence of our judiciary. To them we also owe a determined rigidity and conservatism — the law is the law. That it also be fair was, of course, a desirable goal, and to that end the common law could be made to change, slowly, or by the engrafting of exceptions. Whatever the ultimate aim, it remained, and still remains, the law in the meantime. The same is true of statutory codes. Conduct may be unethical, inequitable or unconscionable, but not necessarily illegal. How often in recent times have we heard the words: "I didn't do anything illegal?

But our inherited judicial system developed antidotes. Persons lacking legal redress for unconscionable wrongs would seek recourse by petition to the sovereign in the original case, the King, who in England quickly turned the job over to the Chancery, an administrative secretariat headed by the Chancellor. It was a natural choice, since the common law writs originated in the Chancery offices, and the clerks were learned bureaucrats. The Chancellor himself might be legally trained and originally the office tended to be held by ecclesiastics, Roman Catholic cardinals, even saints in the case of Becket and More, perfect vehicles for dealing with matters of conscience. There developed then a Court of Chancery where equity, not law, was administered.

The relief was flexible, ad hoc, of a personal nature. Inevitably the equity court came into conflict with the law courts, whose judges regarded with deep suspicion the actions of a king's prerogative court dispensing non-legal justice. The conflict, epitomized by what is referred to as the Coke (judge) — Ellesmere (Chancellor) dispute, reached an uneasy truce in the reign of the Tudors as the result of a royal commission. In consequence the equity court was regarded as having no jurisdiction where there was an adequate legal remedy, and that an equitable decree could not operate to change the legal rule in any way. It could, however, be made to operate personally against an individual who might be operating legally but unconscionably. Shakespeare, who possessed a remarkable insight as to how the system worked in his time, described it in the *Merchant of Venice*. The law gives the creditor his pound of flesh — but equity requires that he shed no blood to obtain it. Note that the law is respected, but indirectly prevented from working in an unconscionable fashion.

There is nothing strange about all this. In fact, we repeatedly use the dichotomy of law and equity in our day-to-day dealings. For example, when we encounter the technical, legalistic bureaucrat who insists on going by the statute book, our reaction is simply to ask for the manager or whoever is in charge, so that a petition can be made to his or her equity and good conscience.

For more than a hundred years, attempts have been made to simplify our judicial system by merging law and equity, and procedurally this has been accomplished. We no longer, with a few exceptions, have separate courts of law and equity. Our superior court judges perform the functions of the Chancellor when circumstances call for the discretionary exercise of what is called "equitable jurisdiction." But substantive merger of the two cannot be obtained. Of course, the law can be amended by incorporating an equity principle, but this is not a merger; it is merely a new law. The function of equity is to exist outside the law, to be invoked as an ethical monitor of the law's performance. Conceptually as well as functionally it escapes merger.

What does this have to do with computers? The computer is the perfect instrument for compiling every jot and tittle of the law, its every conception, and its every instance of application. It can be programmed to personify the ideal technical, legalistic, "go by the letter of the rule book," common-law judge. But it cannot replicate the ad hoc, subjective resolution of disputes between humans that originate in the Chancellor's conscience. The ancient rebuke of equity as a roughish thing which varies as the length of the Chancellor's foot has within it a current truth concerning computers. They cannot be given the measuring stick to do the job.

Perhaps the fact that computer science and the law are so perfectly compatible will be of great benefit in the administration of so-called justice. The almost instantaneous recall of applicable precedent, or statute, the possibility of virtual uniformity of application, the sense of certainty we have that the computer printout is *the* final and accurate statement of the law is all very appealing to many of us. Yet, I cannot but somehow feel grateful that the quality of mercy is not to be strained through a silicon chip.

Footnotes

[1] *Whalen* v. *Roe*, 429 U.S. 589 (1977).

[2] *Tandy Corporation* v. *Personal Micro Computers, Inc.* (D.C. Cal. 1981) 524 F. Supp. 171.

[3] *Mazer* v. *Stein*, 347 U.S. 201.

[4] *Parker* v. *Flook*, 437 U.S. 584.

[5] 101 S. Ct. 1048.

[6] *Wall Street Journal*, April 8, 1982

[7] 248 U.S. 215.

11

A TELECOMMUNICATIONS SURVEY

Paul S. Heller

Paul S. Heller is executive director of EDUNET, an international computing network for higher education and research. Mr. Heller has served as editor of EDUNET News *and authored several articles on networking.*

During the past year there has been rapid growth in the use of computer-based electronic mail systems. Electronic mail is used for communication among colleagues on a given campus and, more recently, among peers on different campuses. Campus-based electronic mail systems have proven convenient and effective for local users. Distant users find such systems useful but relatively expensive and inconvenient. The Mailnet service currently being developed by EDUNET and EDUCOM will provide a means for electronic mail communication with distant colleagues by linking numerous local systems together. Each user will have the convenience and low cost of a local system even when communicating with persons elsewhere in the world. Operators of local (e.g., campus) mail systems will be able to connect to Mailnet without having to acquire any new equipment or to modify existing equipment or operating systems.

THE EMERGENCE OF ELECTRONIC MAIL

The term "electronic mail" has been applied to many different types of messaging service. In this article the term is used to describe computer-based systems in which individuals use an interactive terminal with keyboard and printer or visual display to enter, edit, manipulate, file, or display textual messages. While electronic mail

EDUCOM Bulletin, Summer 1982.

may be printed as a convenience to the user, no paper is required. File copies of messages are stored on the system and no traditional paper filing cabinets are needed. Electronic mail is usually considered a principal component of the "paperless office."

Almost all computer systems have some primitive form of electronic mail capability. At the simplest level, a computer user may create a file on his/her account and give another person instructions on how to access that account and print the file. Such primitive systems are generally used only by "computer types" because they require a knowledge of the computer operating system and lack most of the important convenience features necessary for use by persons without substantial computer experience. Examples of convenience features are notification of new messages, selective filing and retrieval, group distribution, answering, and forwarding.

In recent years many organizations, including universities, have developed or acquired electronic mail systems that are easy to use and have far more functionality than earlier, more primitive systems. There are many examples of well-developed university-based electronic mail systems. At the University of Wisconsin-Madison, a system called EDUMAIL/MACC-Mail is used locally by several hundred faculty and staff and nationally through EDUCOM's EDUNET network by more than 100 users. Cornell University has developed a mail facility based on its IBM system that is used extensively by computer center staff with more extensive local use anticipated when user documentation is completed. A repackaged version of the Cornell mail system is used nationally by business and planning officers at more than 100 colleges and universities that access EDUCOM's EFPM modeling system through EDUNET. A system called EIES (Electronic Information Exchange System) at the New Jersey Institute of Technology has several hundred users throughout the U.S. and in other parts of the world. The CONFER system at the University of Michigan and Wayne State University has several thousand local and remote users with a total usage of several thousand connect hours per month. Both EIES and CONFER are conferencing systems which have features for organized group discussions in addition to electronic mail functions. Stanford, MIT, Dartmouth, University of Virginia, Dickinson, University of Stockholm, University of Southern California, and dozens of other colleges have well-developed mail systems. Numerous commercial systems are also in use, including GTE Telenet's Telemail, Computer Corporation of America's COMET, and Bolt Beranek and Newman's INFOMAIL.

INTER-ORGANIZATIONAL COMMUNICATIONS

Within an organizational unit such as a campus, electronic mail has

proven to be highly effective for communicating messages and authoring and sharing documents. For example, at Stanford University several hundred persons, including the most senior administrators, are using an electronic mail system called CONTACT/EMS (formerly called TFM — Terminals for Managers), a system based on Wylbur (a powerful text editor) and SPIRES (a database search and retrieval system) for creating and sharing textual information varying in length from one line to 100 pages or more. For the staff at Stanford, this is a very effective and convenient means of communicating. The CONTACT/EMS system at Stanford is easy to use, well documented, powerful, and flexible. It is connected to two data communications networks which enable persons around the country to access the system using ordinary terminals. It might seem that an obvious solution to the need for inter-organizational communication would be to have everyone in higher education use a single system such as Stanford's. Although such an approach is possible, it suffers from severe behavioral, technical, and economic impediments. These impediments, which apply to the use of any electronic mail system foreign (i.e., remote and/or unfamiliar) to the user, include:

1. the need to establish an account on the foreign mail system
2. the need to learn the access procedures and the commands for text creation and editing
3. the inability to use screen-oriented editors due to bandwidth limitations of the communications networks
4. the communications costs of being connected to a remote computer during the slow process of composition, text entry, and editing
5. the need to re-key information on the foreign system when it may already be entered on the user's local system
6. the need to check (sign-on) the foreign system regularly to see if there are new messages
7. the fact that many campus terminals are directly connected to the local system and do not have the communications adaptors (e.g., acoustic coupler) required for accessing remote systems.

In spite of these impediments, there are many highly motivated groups of geographically distributed persons now using electronic mail for routine communications. For example, about fifty management and behavioral scientists from different organizations use the Telemail electronic mail system through EDUNET for discussions related to their common interest in the field of organizational development. As another example, a group of senior administrators from twenty-five colleges that are members of COFHE, the Committee on Financing Higher Education, have begun to use Stanford's electronic mail system for routine interorganizational correspondence.

Several other multi-organizational, inter-disciplinary, or special interest groups in higher education use mail systems in similar ways. While other dispersed groups will adopt this approach of picking and using a foreign mail system, cost, limited audience, and inconvenience will prohibit its widespread use by hundreds of faculty and staff on each of dozens of campuses.

The widespread inter-campus use of electronic mail requires a strategy that recognizes the importance of user convenience, minimal change in the current campus computing environment, and reasonable cost. The Mailnet service directly addresses these issues.

THE MAILNET CONCEPT

The essential characteristic of Mailnet is that a user can create, send, and receive messages and documents on his/her own local electronic mail system even if the correspondent is a user of a totally different system. As far as the user can tell, correspondence with foreign users is virtually the same as interaction with local users. In this Mailnet environment, many, if not all of the impediments associated with use of a remote mail system are eliminated.

A simple example can be used to illustrate the Mailnet concept. Foggy Bottom University has many faculty and staff who are users of the FOGMAIL electronic mail system developed at FBU and running on the FBU computer. Brian Bottom, a faculty member at FBU uses FOGMAIL and is known as BBottom to his campus colleagues. The situation at Dry Gulch College is similar, except that the mail system in use there is called DRYMAIL. Linda Gulch, known in DRY MAIL as LindaG, is a routine user of DRYMAIL. Both Brian and Linda have mastered the text editor available to them, and use their local mail systems daily for both short messages to campus colleagues and longer memos and papers.

If both Foggy Bottom and Dry Gulch are participants in Mailnet, then Brian and Linda can exchange messages with each other in the same way they each exchange messages with their local colleagues. Brian would use FOGMAIL to prepare the text of a message to Linda. Brian might address the message as follows:

To: (External) LindaG @ DGC1

The FOGMAIL processor would recognize the keyword "External" and would place the message (with Linda's address) in a file labeled "Outbound Foreign Mail," where it would wait for pickup by the Mailnet system.

Within a few hours, the Mailnet relay computer (hub) would place a direct-dial telephone call to the FBU computer, log on, and retrieve and store the contents of the outbound foreign mail file which contains the message for Linda. Within another few hours the Mailnet

relay computer would dial-up the Dry Gulch computer, log on, deliver to DRYMAIL Brian's message to Linda and pick up all the outbound messages from Dry Gulch. The next time Linda signs on to DRYMAIL she will find the message from Brian.

The power of the Mailnet strategy is that inter-organizational electronic message exchange has been achieved with almost no change in user behavior. Note that both Brian and Linda use the accounts, access procedures, mail system, and editor (perhaps a screen editor) with which they were already quite familiar. As will be explained in detail in a later section, neither computer center has acquired new equipment. It is also true that other faculty and staff on the respective campuses could communicate in the same way that Brian and Linda did. And finally, the Mailnet hub could contact dozens or even hundreds of campuses in the same way it contacted two campuses.

MAILNET OPERATION — AN ANALOGY

An analogy can be used to describe the way in which Mailnet functions. Assume that there are four campus-based electronic mail systems, each of which has a set of local users. In the analogy, the "Central relay" or "Hub" is a trained clerk with an ordinary terminal and an ordinary dial telephone. The clerk has been trained to be able to dial each mail system, to print out any "outbound" mail, and to enter messages. Using the example from the previous section, the clerk dials the FBU computer, signs on, and picks up outbound mail including the message from BBottom to LindaG. The clerk sorts the messages placing all messages for a given destination in a separate stack. The clerk terminates the connection with FBU, and repeats the process with another mail system. When the clerk gets to Dry Gulch, he signs on, prints outbound messages, and enters the Dry Gulch stack of messages (including the message for LindaG) that came from other campuses. A complete message exchange requires that the clerk make the rounds twice.

In fact, one or more clerks could be hired, extensively trained, equipped with terminals and telephones, and the Mailnet concept would be implemented. It should be noted that the operators (i.e., the computer centers) of the several campus mail systems need not acquire any hardware or special communications facilities since existing dial-in ports and ordinary dial-in telephone service are used. The clerk would require training since he/she needs to know how to log on to each campus system. In addition, the clerk would need to know how to tap the outbound and inbound message areas on each system. It is also true that there could be errors in message content or in the addresses due to "noise" on the line or due to transcription errors made by the clerk.

A clerk-based Mailnet service could be easily implemented though it would not be cost effective. The clerk would work at human speed rather than machine speed, resulting in high labor costs and long and therefore expensive connections to the campus systems.

MAILNET — SOON, A REALITY

By implementing the functions the clerk performs on a flexible computer system, the Mailnet service can be quite cost-effective in moving electronic mail among a large number of campus-based systems. A similar computer-based "hub" has been in operation at the University of Delaware under the direction of David Farber. Initially used by several U.S. Army sites, the techniques developed by Farber are now being used by several computer science research groups.

During the past year EDUCOM has investigated the feasibility of establishing the service called Mailnet to provide inter-campus exchange of electronic mail in the higher education and non-profit community. EDUCOM and MIT, in cooperation with sixteen other universities, have now begun to implement this service.

The computer-based hub will be established on the Honeywell/ Multics computer system located at MIT. This facility is ideal for performing the hub functions because it is a secure and reliable production facility with a variety of software tools that facilitate development of a complex communications-intensive subsystem such as Mailnet.

The hub machine will perform all of the functions performed by the clerk in the analogy. The hub will be programmed to contain all of the procedures the clerk would have used to dial-up and log on to the various campus systems. To facilitate maintenance and inclusion of new sites (i.e., new campuses), these procedures will be embedded in tables with one procedure table for each site. The hub also needs to know when to contact each site. A separate set of schedule tables will permit each participating campus to decide when their system should be contacted by the hub. Some sites will opt for message exchange each night when telephone costs are lowest. Other sites desiring more frequent service might exchange messages with the hub several times a day.

In the clerk analogy, the clerk dealt with messages that had different formats or "envelopes," and the clerk also made decisions about how to handle a message to multiple recipients and how to respond to a variety of error conditions. In these circumstances a clerk is far more flexible, adaptable, and creative than even the most complex computer system. With a computer-based hub it is preferable to adopt a standard "envelope" and a standard convention of protocol for the exchange of messages. Adoption of these standards will require some

programming effort on the part of each local mail system operator (each school). The standards to be used in Mailnet will be either those recently developed by the National Bureau of Standards or those used in the Department of Defense ARPANet Network.

A computer-based hub has the advantage over a clerk in being able to avoid errors caused by "noisy" lines. Each Mailnet site will be provided with a program (written in FORTRAN or Pascal) to detect and correct line errors in transmission. This error correction program can be installed easily at each site without modifying the local operating system.

An additional function to be implemented on the hub computer is a complete set of accounting and management reports. Many, if not most, subscribers will need detailed information about message activity in order to rebill users in the customary way on each campus. In addition, both subscribers and EDUNET/EDUCOM staff will need reports to manage Mailnet and monitor each subscriber's participation.

SUBSCRIBER IMPLICATIONS

A campus or departmental computing facility wishing to connect to Mailnet must have electronic mail software on their local computing facility. A variety of sources for such software now exist, including computer manufacturers, commercial software houses, and educational and non-profit institutions.

A campus computing center wishing to connect to Mailnet will need no additional hardware. Existing dial-in communications ports will be used, and modifications to any hardware or to the operating system are unnecessary. A copy of the error control program (in FORTRAN or Pascal) will be provided to each site and installed by site personnel in one to two days. A few sites may need to modify the code extensively or rewrite it in another language, a task which may take two to three days. The effort necessary to embed the standard Mailnet message envelope and message exchange conventions into the local mail system will vary widely depending on the design of the local mail software. Most sites will be able to incorporate the envelope in three to ten-person days. An additional five-person days will be needed for testing. These estimates are based on experience in computer science departments connecting to a similar relay system at the University of Delaware.

While fees for expanded participation in Mailnet will be based on the experience gained from the sixteen pilot sites, it is projected that a one-time implementation fee of approximately two thousand dollars and a similar annual fee will provide adequate funds to operate, maintain, and enhance the Mailnet service.

OPERATING COSTS

One of the attractive characteristics of Mailnet is that the operating costs are low. There are three primary operating costs associated with the day-to-day message exchange operation of Mailnet:

1. Sender site to hub communications
2. Hub to recipient site communications
3. Hub message processing

Each of these costs will vary in direct proportion to the volume of message exchange. The actual communications costs (i.e., the first two listed above) will depend on the particular communications channel used. The most universal communications channel, and that which will be most used in Mailnet, is the ordinary dial-up telephone network. Telephone costs depend on distance, duration of call, and time of day. For those subscribers that for other reasons have connections to one of the data networks (e.g., Telenet or TYMNET), these channels should be used, since they have very low variable costs. (Note: Connections to these data networks involve substantial fixed costs.) The hub message processing costs (reflecting MIT's normal Multics system charges) will be about five dollars per hour of connection time.

Since people think of messages in terms of their length as measured in pages or characters, it is preferable to look at the operating costs on the basis of the cost per one thousand characters or per single-spaced typed page (about twenty-five hundred characters).

The highest charge to send a Mailnet message would be incurred if both sender and recipient are two thousand plus miles from the relay site and daytime direct dial is used in both cases. Based on a direct dial charge of twenty-seven dollars per hour, the total cost for moving a message from sender site to recipient site including hub processing would be approximately twenty cents per one thousand characters or about fifty cents for a typical single-spaced typed page (twenty-five hundred characters).

If the message above were transmitted at night, the direct dial charge will be reduced to eleven dollars per hour resulting in a total cost of ten cents per one thousand characters or twenty-five cents per page. If the sender, the recipient, or both are substantially closer to the relay site, both day and night costs will be reduced further.

If both sender and recipient sites happen to have dedicated Telenet or TYMNET connections, the cost per one thousand characters will be five cents or two to twelve cents per page, regardless of time of day. The wide range here results from the expected wide variation in subscriber policies for recovery of fixed Telenet or TYMNET costs.

These cost estimates are based on the realistic assumptions of 1) use

of transmission speeds of twelve hundred bits per second and 2) a channel efficiency of seventy-five percent.

EDUCOM's experience in EDUNET clearly shows that the prices for use of a service should be easily understood and predictable in advance of use. In addition, the prices should be closely related to cost so that there are few, if any, cross subsidies among participants. These two principles — simplicity and cost — can be embodied in a pricing table that shows the daytime price per page for each pair of sites. A simple discount would be applied for evening and night time exchange.

CONCLUSION

Advances in technology have led to substantial reductions in unit costs for computing and information processing. This has resulted in a dramatic proliferation of terminals, word processors, and personal computers in departments and individual offices. There is also a very clear trend on most campuses to tie these distributed devices to each other and to large campus mainframe computers. This interconnected environment has, in turn, spawned the growth in on-campus use of electronic mail. The Mailnet service takes the next step by providing a painless path for users on one campus to exchange messages and documents with colleagues quickly, conveniently, and in distant locations.

12

THE COMMITMENT OF PEPPERDINE UNIVERSITY TO COMPUTER LITERACY

Howard A. White

Howard A. White is president of Pepperdine University, Malibu, California. He has served Pepperdine University for a quarter of a century in the roles of professor of history, department chairman, dean, and executive vice president. Dr. White has lectured widely and is the author of numerous papers, articles and books.

In 1972 the Carnegie Commission on Higher Education published a report entitled "The Fourth Revolution," which suggested that there have been three major revolutions in education in the country, and we are in the midst of a fourth revolution. The first is said to have occurred when the primary responsibility for the education of our young people shifted from the family to a separate educational institution. The adoption of the written word as a medium for the transfer of information resulted in the second great revolution. The invention of the printing press was the catalyst for the third revolution, allowing large quantities of information to be disseminated in a rapid, inexpensive and reliable manner. The fourth great revolution may well be termed the "electronic revolution," involving the impact of radio, television and especially computers in educational process. We are becoming increasingly aware of changes in society that have been brought about by advances in data processing, and this week we have assembled to examine the ways in which our lives may be changed as a result of the introduction of and the relative availability of microcomputers.

Ten years have passed since the Carnegie Report was published, and the signs of the computer revolution are all around us. The

proliferation of microcomputers on campuses and homes is absolutely overwhelming. Secondary schools expose young people to computers at an outstanding rate. Dr. Arthur Luehrmann, who joined the faculty of this Computer Literacy Institute earlier this week, predicts that by 1984 there will be nearly one-half million microcomputers in American junior and senior high schools. In addition, the uses of computers in management administration, research, construction, production, engineering and everyday life are increasing exponentially.

The introduction of the microcomputer presents great opportunities for the enrichment of the human experience. It also presents immense challenges to institutions of higher learning such as Pepperdine University. It will therefore be the task of these institutions to provide the interface between man and machine. Colleges and universities will be charged with harnessing the great power of the computer to ensure its usefulness as a tool for students in all of the various disciplines. It is the goal of Pepperdine University to meet this challenge with confidence, to face and adapt to the information technology revolution, and to emerge a leader in information technology literacy.

Pepperdine installed its first computer about ten years ago and then moved forward at a rapid development pace. Today the University has well-equipped instructional laboratories on this campus and in each of our three educational centers. More than thirty percent of the student body already is required to use the computer to meet course requirements, and we shall rapidly move toward the time when all students will be so required. The Pendleton Computer Science Center on this campus, which houses the administrative computing department and the mainframe computer, is a model computing structure. The University is developing decision support systems for which it has designed and installed sophisticated administrative support systems that are used throughout the entire University.

Pepperdine's advances in academic and administrative computing have attracted national attention. The University was recently selected along with nine other institutions, including Dartmouth College and Stanford University, to contribute to a book on strategic planning. A task force of administrators and representatives of the various schools and colleges of Pepperdine University was appointed to formulate specific recommendations for the implementation of a University-wide information technology literacy program.

I am pleased to announce that the University fully endorses the recommendations submitted by that task force, and will make a major commitment to information technology literacy. Training and educational programs will be instituted for faculty members of all of our

schools, designed to provide a thorough orientation to computing and the development of computer skills. Over one hundred of our full-time faculty members met with several distinguished panelists in the computer literacy seminar. A videotape education program is already under way for University faculty and staff and additional training programs will be added in the near future. As rapidly as funding is secured the University will make microcomputers available to faculty and students on a University-wide basis. Future plans call for major expansion of the academic computing laboratory and the availability of computers in libraries and educational centers, and even in dormitories.

The University will give high priority to the space and facility needs which will accompany these enhancements. Broad-based faculty committees will be charged with the exploration of short- and long-term curriculum issues including course content, teaching assignments and specific applications of information technology literacy. Courses will be developed where they do not now exist to address the broad issues of information technology literacy. These classes will be designed to impart a body of knowledge about computers, to develop skills in using and programming computers, and to address ethical and societal issues related to computer technology. Finally, the University will commit to providing one-day seminars on information technology for the general public.

To accomplish these goals we will immediately identify ten to fifteen of our greatest needs relating to information technology literacy. We expect to submit proposals to corporations, foundations and other funding sources, confident that there are a great many who share our vision for the future of information technology literacy and who will wish to be partners with us in this great adventure. In the near future Pepperdine University will name an advisory board for information technology literacy to provide leadership and direction for this monumental task. The board will consist of some of the nation's foremost computing authorities from business, education and government.

I have enjoyed this opportunity to share with you our plans for information technology literacy at Pepperdine University. The University is determined to be in the forefront of this movement in higher education and we deeply appreciate the interest you have expressed in this challenge by your attendance here today.

13

THE UNIVERSITY COMPUTER CHALLENGE

Jean-Jacques Servan-Schreiber

Jean-Jacques Servan-Schreiber is founder and director of the World Center for Human Resources and Technology in Paris, France. He is author of the best selling book, The World Challenge *and founded* l'Express, *the largest French weekly magazine.*

I would like to summarize in one sentence the way I perceive America in the summer of 1982, and at the same time, summarize America's very specific responsibilities in the area of information technology. The one large U.S. industry that is still alive and competitive is higher education. All others are going under because of the technological revolution that is computer science, itself invented in America — but used by others.

All of you know of the American industries that have, in a totally unforeseen and disastrous manner, gone into bankruptcy: ship-building, motorcycles, cameras, television, steel, machine tools, automobile industry, petro chemical, etc.

Let us take one example. Let us take the most impressive, the most important example of all. What is happening here is also, of course, happening in Europe. It is the same society, Europe and America. And the problems, the troubles and dramas that you are experiencing here in America, we are experiencing in Europe.

Consider the American automobile industry. First of all, it was the most important of all. It is employing, with all of its affiliations, close to one active American person out of five. It was, until three or four years ago, the dominating automobile industry of the world.

This year, America is making less cars than Japanese industry. General Motors, Ford and Chrysler together, just to compete or to try

to compete in 1985 with the automated industries of Japan (from computer science) need a seventy-billion-dollar investment program. Few experts believe that the automobile industry will really find their seventy billion dollars.

Your newspapers, and especially *The Wall Street Journal* which we are able to read in France the same day as you are, is very much focused on these things. You know the facts. General Motors nearly abandoned its investment in small cars and instead became a dealer for small Japanese cars.

General Motors has a second characteristic. Until last year, one of its affiliate companies was the most promising robot-making company in America, but investment was such and the lag behind the Japanese robot industry was such, that GM has abandoned its own robot industry and entered into a joint venture with the Japanese.

I do not say that with any pleasure, and as I said very specifically, we have the same problems in Germany, England, France, and all the European countries. At the root of this historical drama is the fact that America, for the first time since the Great Depression, is now, like Europe, over ten percent unemployment among the active population.

At the root of this is computer science, and the reason for the failure of your and our traditional industries is a lack of productivity and competitiveness. This is because others, especially in Asia and the Pacific, have seriously taken this science — which you have invented —computer science, to automate their factories years ago.

The drama we face is this: we must computerize our industrial system; we have not in America, and we have not in Europe. Where is your computerized steel industry? Where is your computerized automobile industry? Where is ours? We have no robots, so to speak, and most of the Japanese factories are now fully automated. If we go into robotics, which we could do, we will increase unemployment, at the start. If we do not go into computerization and robotics, we will also increase unemployment because we are not competitive.

This is a dilemma that we should have anticipated for six to seven years, but as Jack Kennedy said of England in the 1940s—the title of his book was *While England Slept*—America and Europe in these five or six crucial years have been sleeping. Now we cannot sleep anymore because social chaos is waiting for us.

The application of personal computing is also a formidable revolutionary force for the development of human capacities, if it is applied to the individual and not only to the machines. That has been forgotten for too long.

We must discover and quickly fund the application of computer science to the individual development of everyone. This you have in your hands. This is the most precious treasure of this great country and

of the world. Your higher education system is still the best in the world and I can testify to that, for many people want their sons or daughters to be able to be taught in American universities.

Now you can measure the urgency of this computer challenge in very practical terms and figures. The Japanese commitment to the robotics program of the nation is very great. The other national program of Japan is what is known as the fifth-generation computer, which as you know is the artificial intelligence development, and for which Japan has also a huge commitment. The second stage of the computer age will lead to personal computers such that people can interface with the machine by voice, gesture and by all human ways of developing the dialogue.

We at the World Center in Paris already have two of these Japanese machines. They are not futuristic. Professors, teachers and academic leaders must not only have this dimension in mind, but must also lead your nation into the consciousness of this very special dimension of computer science.

The computer primarily should develop the faculties of the human being. The machine dimension, the productivity dimension, will develop by itself, but we must make the effort to channel it toward the development of the human being, not in special courses for computer science, but for everyone in all courses of your universities. Computer literacy is a prerequisite for the development of any individual in any field. You can read it in your own newspaper: no one will be able to get a job without being computer literate; not only engineers, not only computer scientists, but all other creative jobs. To be competitive and to have a job, a person will need to be "computer literate."

The other dimension is that the industrial world—the worlds of America, Europe and Japan that are now moving into the post-industrial era—are in a deep state of crisis so they have forgotten the existence of three billion people of the Third World who have no way to create any riches. And these are the only partners with whom we could build a new growth of the world activity. If there is such a deep recession in America and in Europe and all over the world, it is because we have forgotten to equip the Third World with the means to create.

Let us discount now before it is too late the old idea of the distribution of labor by which we could keep in America and Europe the high-technology industry and give away to the Third World our old factories—steel factories, automobile factories, textile factories. We think that they should be happy with this but it is an idea that makes no sense at all. They are not accepting it and for good reason.

We were giving them those factories because they were giving "cheap labor." What cheap labor can compete with the robot that

works night and day without fatigue, without salary, without Social Security? What cheap labor is cheap enough to compete with the automated factory? There is no more cheap labor. The end of an era.

This means that our selfish duty is to give the Third World countries the means by which to transfer knowledge, be creative in high technology, and become computer literate. One of the great discoveries of American science which we have brought to Paris because you have neglected it, is that computer science can be mastered by boys and girls or adults who are illiterate. Someone in Africa or India who cannot read or write can master the computer. This is one of the big aspects of this revolution.

I am not speaking here of theories; it was still theories a year or so ago and now it is at work in these places. One of the first things we have done at the World Center in Paris is to start pilot projects in Africa and Latin America with illiterate populations. These boys and girls are just as good and as fast in mastering the computer. Not the computer with the diskette, but the programming of the computer; they are mastering it in a matter of weeks like the boys and girls in New York or in Paris.

So those are the dimensions we face—the human dimension, the world dimension of this technological revolution which we will be able to master only if your universities and ours bring our boys and girls and then the adults to this degree of capability.

In Paris we gather some of the best scientists in the world to a World Center, devoted to what we call micro-electronics or micro-computer science and human resources. The Center is devoted totally to using computer science for the development of the human being.

I was in the hall of the World Center in Paris the other day; it is open day and night, seven days a week, as it should be. Many kids were there programming their computers and playing with the program. An eight-year-old boy was there working on his computer. A fifty-year-old woman came in. She looked at all the kids programming and said, "Unfortunately, I shall never be able to do that." The little boy who was there working, heard her. He rose by himself and with a very natural initiative went to that lady and said, "Please take my place." She understood the gentleness and the intuition of the eight-year-old boy, and sat at his place, and then he said, "I will teach you." He had been there for one hour. He was making squares, then rotating squares, then spirals. And he said to this lady, "Do what I say, and then you will program in less than half an hour." She did. Not a big program, you understand. But in half an hour, this thing of which she was so afraid, that she thought was too strange to ever become something that she could master, she did under the sweet, gentle instruction of this young kid. This is the wave of the future.

This is what you have in your hands, this tender and crucial treasure. It became official French policy. The document President Mitterand presented as the policy of our country and the suggestion for a common effort of the world was exactly this: the employment of this new technology for new growth and new jobs.

Now, I have been very frank with you of how I see the present, this option of America's vast, powerful, glorious industry, the lagging of America that has forgotten the science that it has invented. The fact that university leaders are now, like in Europe, so isolated from the social hurry of this country, from the industrial establishment, from the political establishment, is not understood. They are not in Europe either. So this science has been taken by others who have applied it with more intelligence and more force.

I speak as a friend. Forty years ago, I was a pilot in the American Air Force, as a cadet under General De Gaulle. Forty years later, every one of my four sons is coming to study computer science in summertime in one of the American universities, at the same time that they go with their studies in France. This is my love and my respect for America. If I share with you such frankness, it is because of that love and respect. Thank you.

Synopsis

THE COMPUTER CHALLENGE

James I. Penrod

James Penrod is vice-president for Systems and Planning at Pepperdine University, where he is currently guiding an institutional thrust toward computer literacy for all students and staff members. He served as director of the institute described in this book and will continue in that capacity for future institutes. Dr. Penrod is a member of the CAUSE Board of Directors.

During the week of June 20, 1982, thirty college and university administrators met on the Malibu campus of Pepperdine University for five days of intensive computer literacy study. This live-in institute, sponsored by CAUSE, EDUCOM and Pepperdine, was designed to help educational leaders with little or no computer background become familiar with some of the basic issues institutions of higher education must face as we become a computer literate society.

The institute began Sunday afternoon with a reception for participants at Brock House, the President's residence overlooking the Malibu campus and the Pacific Ocean. The reception was followed by dinner and an opening address by Arthur Luehrmann.

The daily schedule included two or three morning discussions by prominent speakers on topics related to computer literacy in colleges and universities. Afternoon sessions focused on hands-on exercises with CPT 8100 word processors configured with 96KB CPM-based microcomputers. During the week, participants were introduced to Super Calc, Wordstar, and dBase II software packages.

The evening events included a laboratory session where participants completed assignments, used Stanford's contact EMS electronic mail system, played electronic games, or tested some of the major

microcomputers. Each evening concluded with small group discussions aimed at integrating concepts presented during the day.

The week ended with a series of events which included a wrap-up panel session by institute speakers for participants and members of the Pepperdine faculty. This was followed by a luncheon with approximately 300 guests of the University present where Howard A. White, president of Pepperdine University, gave an address outlining institutional goals for computer literacy. The institute concluded with a keynote address by Jean-Jacques Servan-Schreiber.

Brief highlights of the presentations made during the institute follow.

Arthur Luehrmann, co-founder of Computer Literacy, a Berkeley, California-based firm, spoke on "Computer Literacy—How Do Colleges and Universities Prepare?" Some of the points he made included:

—Microcomputers are rapidly becoming fixtures in high schools, junior high schools and elementary schools.

—Within two to three years it will not be uncommon for entering college students to have had as many as four solid computer courses.

—Computer literacy is a necessity for all disciplines, not just the sciences.

—Colleges and universities must realistically face the "supply and demand" problem for faculty qualified to teach computing.

—There is an enormous market opportunity for higher education, particularly in schools of education.

Mike Roberts, deputy director for the Center for Information Technology at Stanford and the first CAUSE president, delivered "A Technical Introduction To Computing." A few of the ideas he presented were:

—The computer industry is only thirty years old and has had four generations.

—Machines with 100 million instructions per second capabilities, Winchester disks with multiple megabyte capacities for a cost of less than one thousand dollars, and video disks capable of storing one hundred thousand pictures for a cost of ten dollars to twenty dollars illustrate 1982-1983 state of the art.

—Programming and data manipulation are rapidly moving into the hands of the end user.

—Data centers must now begin to deal with the problem of multiple generations of software; maintenance of four or five generations is counterproductive.

—Technology will improve as much in the next four years as it did in the last four.

—The ten million instructions per second, ten gigibyte microcomputer will be available by 1986.

—The American Telephone and Telegraph Company is now in the computer industry and will have a major impact.

Charles R. Thomas, executive director of CAUSE, gave "An Overview of Computing in Higher Education." His points of discussion included:

—There is a contrast between administrative computing in higher education and industry, e.g., an industry data center normally runs ten to fifteen systems as opposed to an educational data center with thirty to forty systems. The number of transactions related to a system, however, is much higher for industry than for education.

—The range of cost for computing in higher education today is about one to four percent of the institution's operational budget.

—Senior administrators should analyze the ratio of administrative computing costs to total administrative costs as a measure of productivity.

—The information resources management organizational model is evolving in higher education.

—Institutions must decide what level of computer literacy they wish to support (elective, literacy, skill, or foundation) and plan for meeting resource implications.

"Typical Applications in Administration, Instruction and Research" was the topic discussed by Ronald J. Langley, director of Data Processing and Information Systems at the California State University, Long Beach campus and the current president of the CAUSE Board. Langley's remarks included the following:

—Instructional computing usually has to do with the areas of programming languages, library (canned) programs, and computer-based learning (CAI, CMI).

—Computing related to research is divided into data analysis and retrieval, computation, simulation and modeling, laboratory equipment monitoring and control (CAD/CAM), and bibliographical search.

—Administrative computing systems normally include student data, business and finance, payroll and personnel information, facilities management files, and development records.

—Micro, mini and mainframe applications are all appropriate in instruction, research, and administrative areas and careful planning is needed to ensure effective matching.

—A portable microcomputer with a built-in Winchester disk and a very low cost will soon be on the market.

Daniel Updegrove, director of Planning Model Activities for EDUCOM, discussed "Modeling and Simulation" and gave a demonstration of EFPM. The following ideas were presented:

—Experience in colleges and universities has shown that modeling leads to the evaluation of more alternatives and to a better understanding of the variables under consideration.

—To successfully model, institutions must have executive level support, appropriate staff, data, and software.

—The goal of an administrator interested in modeling should be to get a modeling system, not a model.

—A good model is simple, complete, easy to control, comprehensive, adaptive, and stable.

The manager of Office Systems for IBM, Sam Kalow, spoke on "The Automated Office." His points included:

—Office technology (writing) changed very little for almost four thousand years from its invention until the mid-1800s. Then electricity, telephones, typewriters and adding machines brought rapid change.

—Little occurred between the 1900s and the 1940s when magnetic storage was invented.

—The next major impact on office technology will be due to satellite communications.

—Today approximately fifty-three percent of all U.S. workers are in the office and the number is increasing.

—A typical document produced in an office is reproduced ten to twelve times. The chances of retrieval after a document is filed are two to four percent.

—Networking telephones, electronic mail/files, computers, videodisks, TV and word processors will significantly impact how we communicate.

—Automating an office requires analysis and planning for space, furniture, heating and air conditioning, and power, as well as hardware and software.

—A good productivity measure in office automation is the amount of reduction of redundant activity.

—People must be trained to take full advantage of increased office productivity, otherwise opportunities will be lost.

John McCredie, president of EDUCOM, made two presentations at the institute. "Systems Integration" was the title of the first and some of the key ideas were:

—A system was defined as being bounded and consisting of inputs which through operation of the system are transformed into outputs. Finally a feedback mechanism allows modifications to take place in the process.

—Integration is the process of making systems work together for a higher purpose.

—Although some plug compatible subsystems are available, the lack of standards in the U.S. is a major problem for systems integration.

—Long-range planning is one of the major keys to successful systems integration.

—Integration is particularly important in the university setting because information processing is the core of what happens in a university.

—Information technology is different from other technologies since it can embody intelligence within it.

—The video disk has tremendous potential for education when it is integrated with a microcomputer.

—Due to technical, financial, and emotional reasons the trend in computing is away from centralized mainframes. This requires the integration of maxis, minis and micros.

—It is crucial for universities to organize for integration. Typical information resources management organizations blend computing, telephone, cable TV, printing, campus mail, word processing and the library into one division.

The second address by McCredie was "Data Base Management Systems." Following are some of the points presented:

—Some fifty-plus data base management systems are available; however, the top four account for eight-five percent of all installed systems.

—The trend appears to be toward DBMS supplied by the major mainframe vendors.

—There are three types of data representatives: hierarchical, generalized network, and relational.

—Relational DBMS's are becoming more popular because of "user friendly" features.

—Elements which should be considered in evaluating DBMS are the data element dictionary, the screen generator, query capabilities, the high level language interface, and modifications of schema processes.

—Costs for DBMS range from $30,000 to $120,000 for large systems and $500 to $1,500 for microcomputer systems.

The associate director of the institute, John F. McManus, director of Academic Computing at Pepperdine University, spoke on "Computer Literacy In Colleges and Universities." His comments included the following points:

—It has been forecast that seventy-five percent of all jobs in the U.S. will require information processing literacy by 1985-1986.

—Literacy in computing is becoming recognized as a vital element in a good liberal arts curriculum.

—Colleges and universities are obligated to provide literacy training for faculty, staff and administration as well as students.

—Institutions that move quickly in becoming information processing literate will have a competitive edge.

—Five selected institutions with announced computer literacy plans were contrasted.

—Computer literacy is a subset of information processing literacy. Definitions of either should be flexible, evolving, and school or perhaps program specific.

—The moral, legal and social implications of the computer revolution should be addressed in literacy programs.

—Strategic planning is needed to successfully implement information processing literacy.

Larry Craft, director of Administrative Services for Systems and Computer Technology Corporation of Malvern, Pennsylvania, discussed "Decision Support Systems." Some of the ideas he presented were:

—An integrated data base, modeling system(s), a query language, and personal work stations are needed to develop a DSS.

—Management information systems have been minimally useful in planning or in improvement of decision effectiveness; DSS are designed to overcome these shortcomings.

—MIS provide data details; DSS summarize information.

—DSS are needed at all organizational levels although most interest is at the executive level.

—A DSS is not a stand-alone resource; its implementation requires significant assumptions and it is expensive.

Distinguished Professor Kenneth H. York of the Pepperdine University School of Law gave a midweek luncheon address on the "Ethical and Legal Issues of Computing." Highlights of York's speech included:

—Examples were given of the misuse of computers including both pranks and sophisticated white collar crimes.

—There is a growing number of books and major articles by the legal profession dealing with the subject of computing.

—Illustrations were given of the increasing number of legal precedents regarding computing.

—An overview of the legal rights of control of computer technology was presented.

—Patents, copyrights, and trade secrets as they apply to computing were contrasted from a legal perspective.

—It was noted that a LEXIS search seeking citations where the words "ethics" and "computer" appeared close together produced nothing.

—A computer has no conscience and cannot be programmed to have one or to be "ethical."

—Conduct of people (who may operate computers) may be unethical, unequitable or unconscionable, but not necessarily illegal.

—The computer is the perfect instrument for compiling every jot and tittle of the law, its every exception, and its instance of application.

—We should, however, feel grateful that the quality of mercy is not to be strained through a silicon chip.

"A Telecommunications Survey" was presented by Paul Heller, the executive director of EDUNET. Some of the information shared by Heller was:

—The speeds of various communications devices were compared.

—Transmission rates for data between micros, minis and mainframe computers were contrasted.

—Definitions for basic telecommunications terms were given.

—Broadband and baseband local area networks were described and advantages and disadvantages of each were listed.

—Various national networks are now available.

—Satellite service through an eighteen-inch dish costing about two hundred dollars is now available, but such services will not replace cable TV.

—Electronic mail is asynchronous and provides rapid delivery, an automatic record, and a machine-readable message. Due to cost and poor regular mail service, it will grow.

—Mailnet linking sixteen pilot schools in the U.S. and one in Sweden will begin operation in 1983. It may become the link for inter-university communications.

Howard A. White, president of Pepperdine University, spoke on "The Commitment of Pepperdine University to Computer Literacy." His major points included:

—The Carnegie Commission has noted that we are experiencing the fourth major revolution in education, the electronic revolution.

—It is the task of institutions of higher learning to provide education for the interface between man and machine.

—Pepperdine will strive to emerge as a leader among teaching institutions in information technology literacy.

—Training and educational programs will be instituted for faculty members in all of the University's schools.

—Networked microcomputers will be made available to faculty and students on a university-wide basis.

—Faculty committees will be charged with exploration of short- and long-term curriculum goals necessary for the implementation of information technology literacy.

—Funding proposals will be prepared for corporations or foundations which may choose to be partners with Pepperdine University in sharing its vision for the future of information technology literacy.

—An advisory board of computing authorities from business, education and government will be named to provide leadership and direction for this task.

—The goal of the institution is to have this plan operational by late 1984.

The founder of the World Center for Human Resources and Technology in Paris, France, Jean-Jacques Servan-Schreiber, gave the concluding keynote address. Some of his primary points were:

—The only large American industry that is alive and competitive is higher education.

—Computer science, invented in America, is being far better utilized by other nations to increase industrial productivity.

—The loss of competitive industry (steel, automobiles, etc.) occuring in the United States is also happening in Europe.

—To be competitive the industrial systems of America and Europe must be computerized, utilizing robots on a mass scale.

—The application of personal computing is a formidable revolutionary force for the development of human capacity.

—Significant progress in funding the application of computer science to individual development has been made in the U.S. in the past year; however, the efforts made are not strong or rapid enough.

—The Japanese have committed $200 billion for robotics expansion over the next five years.

—They have also committed $450 billion toward development of the fifth generation computer with artificial intelligence.

—Very soon, computer literacy will be an absolute prerequisite for the development of any individual in any field.

—The technological revolution provides the means for the Third World to leap into the information age and to be creative. It is the selfish duty of the industrialized nations of the world to provide the technology and training to bring this about.

—University leaders in the U.S. and Europe must make themselves heard by the industrial and political establishments and see that technology is applied with more intelligence and more force than it has been to date.

This synopsis was also published in Volume 5, Number 6 of *Cause/Effect*.

Notes

1. The 35 CPT 8100s used in the institute were supplied as a contribution to higher education by the Automated Office of Van Nuys, California and the CPT Corporaton of Minneapolis, Minnesota.

2. Mr. Kalow's presentation was sponsored by the IBM Corporation.

3. Dr. Craft's week-long involvement in the institute was provided by Systems and Computer Technology Corporation.

4. Partial funding for publication of the proceedings was supplied by the Sperry Univac Corporation.

5. The following companies also sponsored special events to help make the institute possible:

Anacomp Micrographics, Long Beach, California
Comco Systems, Inc., Lawndale, California
IBM Corporation, Universal City, California
Integral Systems, Inc., Walnut Creek, California
Systems and Computer Technology Corporation, Malvern, Pennsylvania
Tayco Business Forms, Newbury Park, California

6. Information about the 1982 or 1983 computer literacy institutes may be obtained from:

James Penrod, Director
Summer Institute for Computer Literacy
Pepperdine University
Malibu, California 90265
(Phone 213-456-4173)